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FINAL WORK PLAN

GOLDEN BUTTE MINE SITE INVESTIGATION
USACE CONTRACT NO. DACW05-00-D-0021

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E	Standard Operating Procedures

ACRONYMS

ABA	Acid-Base Accounting
ANP	Acid Neutralization Potential
AGP	Acid Generation Potential
BLM	Bureau of Land Management
CCV	Continuing Calibration Verification
COCR	Chain-of-Custody Record
CRDL	Contractor-Required Detection Limits
CRQL	Contract-Required Quantitation Limits
DQO	Data Quality Objective
FSP	Field Sampling Plan
HDPE	High Density Polyethylene
IDL	Instrument Detection Limits
MG	Million Gallons
MDL	Method Detection Limits
MSL	Mean Sea Level
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MWH	Montgomery Watson Harza
MWMP	Meteoric Water Mobility Procedure
NDEP	Nevada Department of Environmental Protection
OSHA	Occupational Safety and Health Administration
PQL	Practical Quantitation Limits
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAMS	Remediation of Abandoned Mine Sites
ROM	Run of Mine
SOW	Scope of Work
SSHSP	Site Specific Health and Safety Plan
SSP	Site Security Plan
SOPs	Standard Operating Procedures
SQL	Sample Quantitation Limit
TCLP	Toxicity Characteristic Leaching Procedure
TPH	Total Petroleum Hydrocarbon
USACE	United States Army Corps of Engineers
WET	Waste Extraction Test

EXECUTIVE SUMMARY

The Golden Butte Mine is an abandoned mine site in northeastern Nevada located on public lands administered by the Bureau of Land Management. Planning for reclamation activities at the site is being conducted as part of the Remediation of Abandoned Mine Sites (RAMS) program. This Final Work Plan (Work Plan) presents site characterization activities that will be conducted at the Golden Butte Mine to support development of a Final Closure Plan for the site. The objective of the closure plan will be to stabilize potential mine source components (e.g. waste rock and heap materials) and prevent degradation of waters of the state. Data collected pursuant to this Work Plan will be used to evaluate current site conditions, develop reclamation alternatives and determine procedures for final closure.

Based on the current understanding of site conditions, some likely components of the final reclamation plan are shown below. Each of these reclamation components is subject to change, based on the results of field reconnaissance and laboratory testing described in this Work Plan; however this summary provides a general context for evaluating potential data needs and site characterization objectives. The final reclamation plan may consist of, but not be limited to the following components:

- Push a portion of the ore off heap leach pads to allow re-contouring to 3(H):1(V) side slopes.
- Collect drainage from re-contoured heap leach pads and divert to Crushed Ore pond (see below).
- Provide optional diversion connection in drainage system to divert to guzzler, if water quality permits this in the future.
- Determine appropriate sources of borrow material.
- Cover leach pads with soil and re-vegetate.
- Develop evapotranspiration (ET) basin in the Crushed Ore pond.
- Develop leach field for use, with the Barren Pond, as a backup for ET basin overflow.
- Decommission run-of-mine (ROM) and fresh water ponds in place: fold liner over, cover with soil and re-vegetate.
- Test sludges in ROM and Crush Ore ponds and dispose of, as appropriate.
- Install lysimeters in ET basin and leach field for monitoring.
- Cover waste rock with soil and re-vegetate, as necessary.
- Determine extent of TPH contamination and address, as necessary.
- Remove concrete building pads, miscellaneous materials and dispose of properly.
- Develop long-term monitoring and inspection schedules.

This Work Plan presents a summary of existing conditions and past activities at the site. The scope of data collection activities are presented in the Work Plan and specific data collection techniques and supporting information are contained within the Field Sampling Plan and Quality Assurance Project Plan, which are presented as appendices to the Work Plan. A Site-Specific Health and Safety Plan is also presented as an appendix to the Work Plan along with a Site Security Plan.

Several tasks associated with developing a Final Closure Plan are presented within this Work Plan. These include water quality sampling to characterize draindown from the heap leach pads, pond water and groundwater quality. Additional characterization data will also be collected for waste rock and the heap materials. In addition, this plan addresses identification and characterization of a borrow source(s) for cover material, if necessary. Other tasks presented within this plan include preparation of a reclamation cost estimate.

An evaluation of the potential for pond overflow and a proposed action plan will be prepared and presented in a separate, technical memorandum. Hydrocarbon contamination associated with the former tank and building pad area will be addressed separately. This will include removal of the pad, excavation and removal of contaminated soils and soil confirmation sampling.

1.0 INTRODUCTION

1.1 GENERAL PROJECT INTRODUCTION

The Golden Butte Mine (the site) is an abandoned mine site located in White Pine County, Nevada, approximately 45 miles northwest of Ely, Nevada within the Basin and Range physiographic province. The site is located on the western slope of the Cherry Creek Range in Butte Valley (see Figure 1-1, *General Site Location*), at elevations ranging from approximately 6,650 to 7,180 feet above mean sea level (MSL). Access to the site is via Nevada State Highway 93 and dirt roads through the town of Cherry Creek. The site is entirely located on public lands administered by the Bureau of Land Management (BLM). The site consists of an open pit, waste rock disposal area, two leach pads, four operations ponds and ancillary facilities. Mining operations began in 1988 and ceased in 1994. No naturally-occurring surface water exists near the project area (the ponds were constructed with the facility). A site map is provided in Figure 1-2, *Site Layout*, which presents the layout of mine facilities.

This Work Plan presents data collection activities that will be conducted to support development of a Final Closure Plan for the site. The Final Closure Plan will be prepared pursuant to Nevada Department of Environmental Protection (NDEP) regulations as presented in Preparation Requirements and Guidelines for Permanent Closure Plans and Final Closure Reports (NDEP, 2001). The Final Closure Plan will detail procedures for stabilization of all mine source components. This Work Plan presents data collection activities that will be used to support evaluation of reclamation alternatives and development of the Final Closure Plan.

1.2 REMEDIATION OF ABANDONED MINE SITES (RAMS) PROGRAM

The United States Army Corps of Engineers (USACE) established the Remediation of Abandoned Mine Sites (RAMS) program in 1998 to assist in restoration and remediation of non-coal abandoned mines. The program addresses environmental and water quality problems caused by drainage and related activities from abandoned, inactive non-coal mines. The program supports activities and priorities of Federal, State, Tribe and nonprofit entities.

The RAMS program is managed through three regional business centers, Western, Mid-continent, and Appalachian, each of which is made up of multiple Corps Districts. The current work for the Golden Butte mine is being coordinated by the Sacramento District of the USACE and the Ely Field Office of the BLM. The RAMS program is funded by federal appropriations through the Corps Civil Works and Support for Others Authorities.

1.3 PROJECT SCOPE AND OBJECTIVES

The scope for this Work Plan is based on the scope of work (SOW) presented in the March 21, 2002, SOW for the Golden Butte Mine presented to Montgomery Watson Harza (MWH) by the USACE. The objective of the proposed data collection is to provide information that can be used for describing mine facilities, evaluating reclamation alternatives and developing the Final Closure Plan, pursuant to NDEP guidelines. This scope includes the following tasks:

- Hydrologic Analysis of Potential Pond Overflow
- Water Quality Sampling
- Borrow Source Determination
- Leach Pad Characterization
- Waste Rock Characterization
- Mine Reclamation Cost Estimate

Each of these tasks is discussed in more detail in the following sections of the Work Plan. The Field Sampling Plan (FSP) provides detailed information on sampling and analysis procedures associated with each task.

1.4 POSSIBLE RECLAMATION COMPONENTS

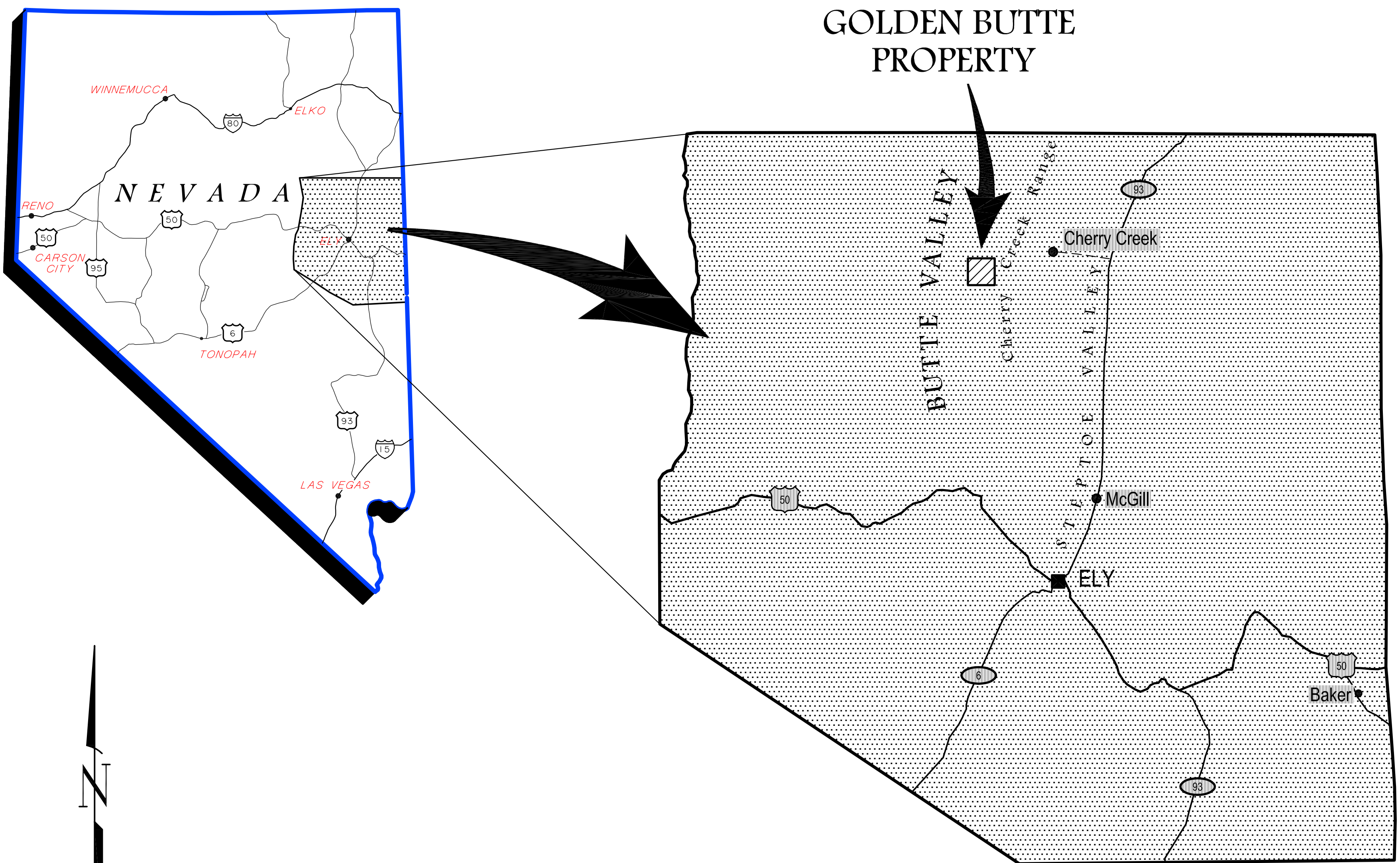
Based on the current understanding of site conditions, some likely components of the final reclamation plan are shown below. Each of these reclamation components is subject to change, based on the results of field reconnaissance and laboratory testing described in this Work Plan; however this summary provides a general context for evaluating potential data needs and site characterization objectives. The final reclamation plan may consist of, but not be limited to the following components:

- Push a portion of the ore off heap leach pads to allow re-contouring to 3(H):1(V) side slopes.
- Collect drainage from re-contoured heap leach pads and divert to Crushed Ore pond (see below).
- Provide optional diversion connection in drainage system to divert to guzzler, if water quality permits this in the future.
- Determine appropriate sources of borrow material.
- Cover leach pads with soil and re-vegetate.
- Develop evapotranspiration (ET) basin in the Crushed Ore pond.
- Develop leach field for use, with the Barren Pond, as a backup for ET basin overflow.
- Decommission run-of-mine (ROM) and fresh water ponds in place: fold liner over, cover with soil and re-vegetate.
- Test sludges in ROM and Crush Ore ponds and dispose of, as appropriate.
- Install lysimeters in ET basin and leach field for monitoring.
- Cover waste rock with soil and re-vegetate, as necessary.
- Determine extent of TPH contamination and address, as necessary.
- Remove concrete building pads, miscellaneous materials and dispose of properly.
- Develop long-term monitoring and inspection schedules.

1.5 WORK PLAN ORGANIZATION

This Work Plan is divided into six sections and five appendices. The first section provides an introduction to the Work Plan, the project scope and objectives. Background information for the site is provided in the second section. Site conditions and a description of mine facilities are presented in Section 3, and Section 4 provides a description of each task contained within the Work Plan. The project schedule is provided in Section 5, and Section 6 lists references cited in this document.

Supporting materials are provided in appendices. Appendix A presents the FSP for the activities presented in the Work Plan. The Quality Assurance Project Plan (QAPP) is presented in Appendix B. A Site-Specific Health and Safety Plan (SSHSP) is provided in Appendix C. Appendix D provides a Site Security Plan (SSP). Standard Operating Procedures (SOPs) are provided in Appendix E.



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GENERAL SITE LOCATION

2.0 PROJECT BACKGROUND

This section provides background information for the site including a general site description and a summary of past activities.

2.1 GENERAL SITE DESCRIPTION

The mine consisted of one open pit that was used to extract gold-bearing ore within hydrothermally altered rocks located along the western slope of the Cherry Creek Range. The mine is entirely located on public lands administered by the BLM. The pit has a depth of approximately 300 feet and covers an area of approximately 19 acres. Mining operations consisted of blasting sulfide ore along benches, crushing the high-grade material to ¾-inch diameter and hauling the ore to the ROM and crushed ore leach pads located downslope from the mine in the Butte Valley.

Gold was extracted via a heap leach process using cyanide and the resulting solutions were stored in the pregnant leach ponds. The gold-rich solutions were then pumped through carbon beds to extract the gold and the remaining solutions were piped to the barren pond. The solution in the barren pond was recycled back to the heap leach pads. Facilities utilized at the mine consisted of the following:

1 - open pit
1 - jaw crusher
2 - cone crushers
1 - screen
1 - waste rock area
1 - ROM heap leach pad
1 - crushed ore heap leach pad
1 - ROM pregnant pond
1 - crushed ore pregnant pond
1 - barren pond
1 - fresh water pond
1 - carbon column processing plant
1 - shop
1 - generator building
1 – reagent mixing building
1 - lime silo

2.2 SITE HISTORY

The original co-owners of the project were Silver King Mines and Pacific Silver Corporation. Alta Gold Company began mining at the site in 1988 and continued operations until 1994. Leaching of the ore continued on a seasonal basis until 1995.

2.3 PREVIOUS/ONGOING RECLAMATION ACTIVITIES

In 1995, reclamation was started under the direction of the Golden Butte Reclamation Plan (Alta Gold, 1993). However, due to bankruptcy, Alta Gold did not complete reclamation. Some bond money is still available for the completion of reclamation work. Reclamation tasks that were undertaken by Alta Gold included:

- Re-contouring and seeding of waste rock disposal area
- Rinsing of leach pads
- Design of bio-reactor (not approved by NDEP)

Currently, some vegetation is present on the waste rock, although in some areas vegetation may be inhibited by low pH caused by sulfide oxidation. Additional investigation of these potential mine source components (waste rock, leach pad and draindown waters) are discussed in Section 4 of this Work Plan.

Both heap leach pads have been rinsed. Prior to bankruptcy, Alta Gold issued a design and application for a leachfield and treatment plant pond (bio-reactor). This was proposed as a permanent and final process to dispose of draindown solution from both leach pads. This proposal was never approved by NDEP; the technical approach was not accepted (NDEP, 1998). Options for final closure of the leach pads and associated ponds will be further evaluated during development of the Final Closure Plan.

2.4 CURRENT SITE STATUS

No mining or processing activities are occurring at the site at this time. Due to the bankruptcy of Alta Gold, the Golden Butte site is an abandoned mine site located on BLM property. The BLM plans to complete reclamation activities for the waste rock, heap leach pads and ponds at the site using reclamation bond money posted by Alta Gold prior to bankruptcy. The site is visited periodically by BLM staff to monitor site conditions.

3.0 SITE/FACILITY DESCRIPTIONS

3.1 CLIMATE

On average, the area receives approximately 8 to 12 inches of rain per year. The 100-year rainfall event is estimated at 2.8 inches over a 24-hour period. Most precipitation occurs during the winter and spring months. The average annual temperature is estimated at 45 to 50 degrees Fahrenheit, with an annual pan evaporation rate of 48 inches.

3.2 PHYSIOGRAPHY

The mine is located within the Cherry Creek Range, at elevations ranging from 6,760 to 7,180 feet MSL. Process facilities are located at approximately 6,650 feet MSL. With the exception of a small spring that developed in the open pit mine, no naturally-occurring surface water is encountered near the project area. However, a topographic map of the site indicates that a seasonal drainage channel exists directly east of the pads.

In general, the site slopes from east to west and the open pit is located in the upper reaches of the site on the western flank of the Cherry Creek Range. Surface water runoff is contained within the pit. The waste rock disposal area is located downslope and to the southwest of the pit. Further downslope the ROM and crushed ore leach pads are located above and drain to the west into the two pregnant ponds.

3.3 GEOLOGY

The southern Cherry Creek Range consists of upper-most Cambrian through Pennsylvanian miogeosynclinal strata with very minor amounts of Tertiary volcanics. The geologic units strike generally north-south and dip to the west. Recent interpretation of the faulting is that it can be mapped as either high or low angle tilted normal faults with approximately 200% extension (Gans, 1982). The project area is underlain by Devonian Guilmette Limestone through Mississippian Chainman Shale. The northern half of the project area is comprised of the Guilmette Limestone and Jasperoid, which occur at or near the contact with the overlying Pilot Shale. A rhyolite dike intrudes the limestone south of the project area and is the only igneous rock exposed in the vicinity.

Well borings advanced in the processing area indicate the site is underlain by an upper layer of alluvium that thickens from 60 feet to greater than 300 feet to the west, below which an unaltered porphyritic latite volcanic rock is encountered. A shallow, low-permeability caliche layer is found below the processing area immediately beneath the soil surface.

3.4 SURFACE WATER

There is no naturally-occurring surface water near the project area. The existing on-site ponds were constructed for mine operations. However, topographic mapping of the site indicates that a seasonal drainage channel exists directly east of the pads.

3.5 GROUNDWATER

Five well borings were drilled to depths of between 300 and 385 feet below ground surface (bgs) in the heap leach pad area in search of mine-process water. These borings extended into the volcanic rock below the alluvium, but no water was encountered. However, groundwater was encountered in two additional borings located approximately 0.5 miles upslope from the leach pads and 1.5 miles downslope and west of the leach pads. These borings were converted to the east and west water wells, respectively (Figure 1-2, *Site Layout*). Static groundwater was recorded (date not reported) at 60 feet bgs (at the contact between alluvium and volcanics) and 70 feet bgs (within the alluvium) in the east and west water wells, respectively. The closest drinking water supply well is 12 miles away in the Steptoe Valley.

3.6 FACILITIES

Heap leach pads and ponds were constructed with a double liner system. The primary liner (for the heap leach pads) is an 80-mil high density polyethylene (HDPE) material with thermally welded seams. Underlying the liner is a 12-inch layer of compacted silt that was placed in two 6-inch lifts and compacted to provide a permeability of 10^{-6} cm/sec.

The pregnant solution ponds and the barren pond were sized to contain a 48-hour draindown from the pads as well as handle a 100-year, 24-hour storm event. The ponds are cut and fill structures with approximately 80% being built in cut. The fill portions were built in 12-inch lifts and compacted to 95% of optimum density. Sideslopes of the ponds are 3(Horizontal):1(Vertical). Pond bottoms were graded to direct potential seepage toward the leak detection system. A 12-inch layer of clayey material was placed over the sides and bottom and compacted. The secondary liner consists of 60-mil HDPE material with thermally welded seams. The leak detection system was installed between the primary and secondary liner. These ponds were permitted to operate as a zero-discharge facility under Water Quality Control Permit #NEV89023.

The process area consisted of a metal building housing six carbon columns as well as two diesel generators. Drainage from the process area was directed across a lined area to the barren solution pond. The reagent storage and mix area was located adjacent to the barren pond. The surface topography was sloped to drain into the lined pond.

All buildings have been removed from the site, with only the foundations remaining in place. The reclamation plan developed for the site will include breaking and burial of the foundations based on BLM and NDEP guidelines.

4.0 PROJECT TASKS

This section provides a brief description of each task proposed as part of the Work Plan. Detailed information concerning sampling and analysis methodologies associated with each task is provided in the FSP in Appendix A. The QAPP, presented in Appendix B, provides project controls designed to assure data quality and collection of data representative of site conditions.

4.1 HYDROLOGIC ANALYSIS OF POND OVERFLOW POTENTIAL

The objective of this task is to determine the potential for pond overflow and to prepare an action plan for addressing this concern, if necessary. Field sampling is not required as part of this task. This task involves a conservative calculation of the potential for pond overflow based on pond capacities and expected draindown from the heap leach pads. Data used for this calculation will include BLM monitoring information, pond storage and capacity data, and climatic data. Simple analytical equations comparing pond capacities to potential draindown, precipitation and evaporation rates will be used to determine the potential for pond overflow.

An assessment of the potential for pond overflow will be presented in a separate, technical memorandum. This memorandum will also contain a proposed action plan for preventing pond overflow, as deemed necessary.

4.2 WATER QUALITY SAMPLING

The objective of water quality sampling is to evaluate current water quality conditions at the site for groundwater, the facility ponds and heap leach pad draindown. The following sections present water quality sample quantities and locations.

4.2.1 Heap Leach Pad Draindown Sampling

One water quality sample will be collected from each of the drainages discharging from each heap leach pad (ROM and crushed ore pads) to characterize pad draindown. Flows will be measured at each discharge at the time of sampling. These samples will be analyzed for field parameters, Nevada Profile II parameters and total cyanide (see Table 4.1, *Water Sampling Summary*). Sampling of leach pad effluent will be generally equivalent with completion of a Nevada Meteoric Water Mobility Procedure (MWMP) analysis of the heap leach pad material in that the unreclaimed pad has been exposed to meteoric water since completion of rinsing operations. (Heap leach pad leachate will also be analyzed using MWMP, as described in Section 4.4). Water quality data from leach pad draindown will be used in the Final Closure Plan to evaluate long-term solutions for handling these fluids. A complete description of sampling and analysis techniques for this task is presented in the FSP (Appendix A).

4.2.2 Well Sampling

One water quality sample will be collected from the East Water Well (described in Section 3.5 and shown on Figure 1-2) and analyzed for field parameters, Nevada Profile II parameters, and total cyanide. Water levels will also be measured in the well before purging and prior to sampling. A complete description of sampling and analysis techniques for groundwater is presented in the FSP (Appendix A).

In addition, water quality data from the West Water Well may be available from NDEP. If available, these data, along with data collected from the East Well, will be used for describing background groundwater conditions at the site, and will be compared with historical information to evaluate trends and identify contaminants of potential concern.

4.2.3 Pond Sampling

One representative water quality sample will be collected from each of the three (3) facility ponds (ROM, crushed ore and barren) and analyzed for field parameters, Nevada Profile II parameters, and total cyanide. Pond water level measurements will also be collected or estimated at the time of sample collection. A complete description of sampling and analytical techniques is presented in the FSP (Appendix A).

4.2.4 Summary of Water Quality Sampling

A summary of water quality sample quantities and locations is provided below in Table 4.1, *Water Sampling Summary*.

TABLE 4.1
WATER SAMPLING SUMMARY

Location	Quantity	Parameters
Leach Pad Draindown (ROM, crushed ore)	2	Field Parameters Flow Nevada Profile II Parameters Total Cyanide
East Water Well	1	Field Parameters Water Level Nevada Profile II Parameters Total Cyanide
Ponds (ROM, crushed ore, barren)	3	Field Parameters Water Level Nevada Profile II Parameters Total Cyanide

A complete listing of analytical (Nevada Profile II, total cyanide) and field parameters is provided in Section 3 of the FSP (Appendix A) in Table 3.1.

4.3 BORROW SOURCE DETERMINATION

A source of soil borrow material will be required to complete reclamation activities at the site. The original Alta Gold reclamation plan estimated that over 14,000 cubic yards (yd^3) of soil would be utilized to cover the heap leach pads. This assessment will be re-evaluated during development of the Final Closure Plan, however it is likely that a source of borrow material will be required. The objective of this task is to locate and evaluate potential borrow areas to provide a source for this material.

4.3.1 Review of Available Data

The first step in the borrow area determination task will be to review all available and pertinent soils data from the area of the Golden Butte mine. Soil maps and descriptions have been received from BLM and will be used to facilitate the borrow source investigation. NDEP has also provided comments regarding potential borrow sources that will also aid the investigation. In addition, it is anticipated that the following sources will be evaluated:

- Review of BLM data
- Review of Natural Resource Conservation Service soil surveys of the area
- Review of Alta Gold soils information

The review of data will also include personal communication with individuals knowledgeable of Golden Butte operations and the surrounding area.

4.3.2 Field Sampling

Borrow areas will be investigated and sampled at the discretion of the field engineer. It is estimated that three (3) samples will be collected and analyzed for potential use as borrow material.

Backhoe trenches or test pits will be used to evaluate the volume of available material in each potential borrow area. Each test pit will be logged in the field and grab samples will be collected, as appropriate. Based on a field determination of the preferred borrow area, and input from the BLM, representative soil samples will be submitted for laboratory testing of the parameters shown below in Table 4.2, *Borrow Source Sample Parameters.*

TABLE 4.2
BORROW SOURCE SAMPLE PARAMETERS

Location	Quantity	Parameters
To be determined based on field identification of source material	~ 3	Agronomic Parameters (1) Geotechnical Parameters (1) Hydraulic Parameters (1) Total Metals Analyses (1)

1) A complete description of parameters included is given below and listed in the FSP.

Agronomic properties include soil pH, electrical conductivity, organic matter, free lime, nitrate-N, available nitrogen, sulfate-S, bicarbonate phosphorus, exchangeable potassium, exchangeable magnesium, exchangeable calcium, exchangeable and soluble sodium, and sodium adsorption ratio.

Geotechnical parameters will include coarse fragment content (>2mm) and standard grain size distribution including a hydrometer analysis for fines passing to 200mm sieve.

Hydraulic properties include initial moisture content, dry bulk density, total porosity, moisture characteristic curve [7 points], saturated hydraulic conductivity and calculated unsaturated hydraulic conductivity function.

The total metals analyses will include antimony, arsenic, cadmium, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc.

A complete description of sampling and analytical techniques associated with this task is provided in the FSP provided in Appendix A.

4.4 LEACH PAD CHARACTERIZATION

Additional sampling will be performed to characterize the physical and chemical characteristics of the leach pad material. Additional characterization of the heap leach pads will allow evaluation of the suitability of the heap leach pads as a reclamation substrate and comparison of metals levels to background information. Existing data from previous investigations or mine operation will also be used to help characterize geotechnical and geochemical properties of the heap leach pads. Results of the geochemical tests will be used to develop a material handling plan for reclamation during development of the Final Closure Plan.

4.4.1 Leach Pad Sampling

Two composite, representative samples of material will be collected from the top 0-24 inches of the crushed ore pad and ROM heap leach pads, respectively. Total metals analyses will be performed and compared to background soils (such as the borrow source). Agronomic properties will also be tested to determine revegetation potential. Geotechnical and hydraulic properties will also be determined for these samples.

In addition, geochemical parameters will be evaluated, consisting of Acid-Base Accounting (ABA), paste pH, and analysis of leachate using MWMP testing. Acid-generating potential will be evaluated using ABA. Acid generating capacity will be determined based on sulfide-sulfur content and neutralization potential will be evaluated using the Modified Sobek technique. A paste pH sample will be analyzed to determine readily available acidity. Leachate produced by MWMP will be analyzed for Nevada II profile parameters and total cyanide.

A summary of leach pad sampling and analytical parameters is provided below in Table 4.3, *Leach Pad Sample Parameters.* A complete description of sampling and analytical techniques associated with this task is provided in the FSP provided in Appendix A.

TABLE 4.3
LEACH PAD SAMPLE PARAMETERS

Location	Quantity	Parameters
Composite samples from upper 24 inches of leach pad (ROM and crushed ore)	2 (one from each pad)	Agronomic Parameters (1) Geotechnical Parameters (1) Geochemical Analyses(1) Hydraulic Parameters(1) Total Metals Analyses(1)
1) A complete description of parameters is included in the FSP.		

Because of the wide variation in the coarseness of the rock material, more than one composite sample may have to be collected and analyzed for hydraulic analysis. Hydraulic data may be limited to information collected from the fine-grained (less than one inch) size material. These data will be sufficient for evaluating the flow characteristics of the fine-grained matrix material.

4.4.2 Reclamation Plan Development

A heap leach pad reclamation proposal will be developed following completion of the required studies. A recommended regrading plan will be developed and, as required, an engineered soil cover will be designed using SoilCover or other applicable models. Information required by NDEP for justification of pushing the rinsed heap material off the lined pad will be included in the plan. Based on the information collected as part of this Work Plan and other existing data, the proposed reclamation technique for the leach pads will be developed as part of the Final Closure Plan for the site. The Final Closure Plan will contain adequate detail for development of a construction cost estimate. The construction cost estimate will be based on quantities generated from the reclamation plan and unit costs for similar work performed in Nevada on other mine projects. Reclamation components included in the Final Closure Plan may be modified after review from NDEP and final design, which could impact final cost.

The information collected as part of this Work Plan will also be used to develop methods for management of existing pond water (e.g. land application) and long-term management of heap leach pad draindown (e.g. leach field or other passive system). These methods and associated costs will be presented in the Final Closure Plan. Data contained in the Golden Butte Leachfield Design Report (Alta Gold, 2000) will be reviewed and utilized as appropriate for evaluating options for fluid handling at the site.

4.5 WASTE ROCK CHARACTERIZATION

Additional sampling will be performed to characterize the physical and chemical characteristics of the waste rock material. Existing data from previous investigations and mine operation will also be used to help characterize geotechnical and geochemical properties of waste rock.

4.5.1 Waste Rock Sampling

A soil pH surface mapping program will be completed to characterize the extent of acid-generating material associated with the waste rock disposal area. The current extent of the acid generation problem on the waste rock pile will be determined through surface pH mapping using the field paste pH test. Sample sites will be biased towards sites with potential sulfide oxidation or limited vegetation (i.e., barren areas). Several samples will also be collected from vegetated areas for comparison. It is estimated that approximately 50 samples will be analyzed in the field for paste pH. Concurrent with the paste pH testing, a surficial map of the waste rock area will be generated to delineate vegetated and barren areas, noting whether barren areas are a result of acidic soils (based on pH testing) or lack of fine material (based on visual inspection).

Based on the outcome of the field reconnaissance and pH survey, two composite samples of the waste rock material will be collected to represent the acid-impacted (barren) and unimpacted (vegetated) areas, respectively. These samples will be analyzed for agronomic, geochemical (ABA, paste pH, and leachate using MWMP for Nevada II parameters (including total cyanide)), and total metals analyses. These data will be used to evaluate potential environmental impacts, including acid generation.

In addition, a field spring survey will be conducted around the perimeters of the waste rock area to determine whether any springs are emanating from the base of the waste rock pile. If any springs are discovered, photographs will be taken and field parameters (temperature, pH, conductivity and dissolved oxygen) will be measured and documented.

The waste rock sampling program is summarized in Table 4.4, *Waste Rock Sampling Program.* A complete description of field and laboratory procedures associated with this task is presented in the FSP (Appendix A).

TABLE 4.4
WASTE ROCK SAMPLE PARAMETERS

Location	Quantity	Parameters
Composite samples of waste rock (barren and vegetated areas)	2	Agronomic Properties (1) Geochemical Analyses (1) Total Metals (1)
Paste pH survey (field)	To be determined in field (approx. 50)	Field (soil) pH
Spring Survey	Survey	Photo Documentation Field Parameters
1) A complete description of parameters is included in the FSP.		

Data generated during the sampling program will be evaluated to determine the long-term acid generation potential of the waste rock and potential implications for reclamation.

4.5.2 Reclamation Option/Cost Estimate Report

The reclamation proposal for the waste rock disposal area will be included in the Final Closure Plan and will contain adequate detail for development of a construction cost estimate. The construction cost estimate will be based on quantities generated from the reclamation plan and unit costs for similar work activities performed in Nevada on other mine reclamation projects.

4.6 EVALUATE POTENTIAL TPH CONTAMINATION

The NDEP indicated in a letter to Alta Gold Company, dated March 8, 2000, that hydrocarbon contamination is evident in surface soils next to the generator and 10,000-gallon diesel tank. The tank has already been removed. Hydrocarbon contamination associated with the former tank and building pad area will be addressed separately. Tasks will include removal of the pad, excavation and removal of contaminated soils, and soil confirmation sampling.

4.7 TOTAL MINE RECLAMATION COST ESTIMATE

A reclamation proposal and associated cost estimate will be developed based on the outcomes from the scope of work contained within this Work Plan. The reclamation proposal and cost estimate will identify the cost of reclamation on a component basis that can be used to prioritize existing bond money available for reclamation. The existing reclamation plan will be used as a guideline for development of the reclamation proposal. Cost estimates for the following tasks will be included:

- Methods identified for stabilization of heap leach pads and waste rock including recontouring and revegetation.
- Analyze pond sludge leachate with MWMP for Nevada II Profile parameters (including total cyanide).
- Characterize pond sludge with Toxicity Characteristic Leaching Procedure analysis.
- Removal of sludge (if necessary).
- Bury pond liners and reconfigure ponds.
- Develop cover for heap leach pads.
- Break concrete foundations and bury on site.
- Removal of site debris.
- Recontouring of haul roads.
- Placement of growth medium on reclaimed sites.
- Cost of seeding all reclaimed sites.
- Long-term monitoring.
- Long-term handling of draindown fluids.

A site-wide reclamation plan will be developed and included as part of the Final Closure Plan for the Golden Butte site per NDEP guidelines. The reclamation plan will contain adequate detail for development of a construction cost estimate. This construction cost estimate will be based on quantities generated from the reclamation plan and unit costs for similar work activities performed in Nevada on other mine reclamation projects. Labor and area rental costs for equipment will be based on the Davis Bacon Wage schedule.

5.0 PROJECT SCHEDULE

A project schedule has been prepared for implementation of work presented in this Work Plan and is presented in Figure 5-1, *Project Schedule*.

5.1 FIELD INVESTIGATIONS

Field investigation activities will begin following approval of this Work Plan. Field investigation work is currently scheduled to begin October 28, 2002, and will be completed in approximately two weeks as shown on the project schedule.

5.2 REPORTS

There will be two iterations of the Final Closure Report that will be developed after completion of the field work described in this Work Plan. The Draft Final Closure Report will be submitted December 20, 2002, followed by the Final Closure Report submitted January 17, 2002. The submittal dates and periods for review are provided on the project schedule.

6.0 REFERENCES

Alta Gold, 1993. *Alta Gold Co., Golden Butte Project Reclamation Plan*. April 26, 1993.

Alta Gold, 2000. *Golden Butte Leachfield Design Report*. Prepared by Fred Retzlaff. April 20, 2000.

MWH, 2001. *Remedial Action Scoping Report – Golden Butte Mine.* USACE Contract No. DACW05-00-D-0021, September 12, 2001.

NDEP, 2001. *Preparation Requirements and Guidelines for Permanent Closure Plans and Final Closure Reports*

NDEP, 1998. Letter re: Land Application, Golden Butte Project. June 9, 1998

APPENDIX A

FIELD SAMPLING PLAN

GOLDEN BUTTE MINE SITE INVESTIGATION
USACE CONTRACT NO. DACW05-00-D-0021

October 2002

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1.0 INTRODUCTION

The Field Sampling Plan (FSP) describes procedures that will be used to assure that samples representative of the physical and chemical characteristics of site media are collected. In addition, the FSP presents methods that will be used during development of the Final Closure Plan for the site (e.g. pond overflow analysis and reclamation cost estimate).

The main activities associated with the FSP are as shown below:

- Analysis of potential for pond overflow
- Water monitoring
- Mine materials characterization (i.e. borrow source, heap leach pad material and waste rock)
- Reclamation cost estimate

The objective of the sampling and work presented in this FSP is to provide the information necessary for development of a Final Closure Plan for the Golden Butte site per NDEP guidance as presented in Preparation Requirements and Guidelines for Permanent Closure Plans and Final Closure Reports (NDEP, 2001).

This FSP addresses several issues that require further characterization prior to development of a Final Closure Plan. These issues include surface water and groundwater characterization, determination of the geochemical and agronomic properties of heap leach pad and waste rock material and identification and evaluation of potential borrow sources. Sampling procedures for characterization of these properties are presented in this FSP.

2.0 HYDROLOGIC ANALYSIS OF POTENTIAL POND OVERFLOW

Currently there is concern that the volume of water that reports to the ponds will exceed evaporation rates and result in pond overflow. A conservative water balance will be prepared to evaluate the potential for pond overflow and prepare an action plan to address this concern. The water balance and action plan will be presented in a separate technical memorandum.

3.0 WATER QUALITY SAMPLING

The primary purpose of the groundwater and surface water sampling is to obtain additional physical and chemical data to support development of the Final Closure Plan for the Golden Butte Mine site.

3.1 OBJECTIVES OF THE WATER QUALITY SAMPLING PROGRAM

The primary objectives of the water sampling program are to supplement existing water quality data characterizing heap leach pad draindown and pregnant pond water quality, and to collect additional data for evaluation of background groundwater quality at the site. Water monitoring will be conducted at the following locations:

- Run of Mine (ROM) Pad draindown;
- Crushed Ore (CO) Pad draindown;
- ROM pregnant pond;
- CO pregnant pond;
- Barren Pond; and
- East Water Well.

3.2 WATER QUALITY SAMPLING ACTIVITIES AND PROCEDURES

The water monitoring program will include measurement of field water quality parameters, flow, pond water levels, groundwater levels and collection of groundwater and surface water samples for laboratory analysis. All activities will follow the procedures summarized below and detailed in the project standard operating procedures (SOPs). SOPs that cover water monitoring activities are presented in Appendix E and include the following:

- SOP-1, Collection of Surface Water Samples
- SOP-2, Collection of Groundwater Samples
- SOP-3, Surface Water Flow Measurement
- SOP-4, Collection of Water Level Measurement Data

The SOPs provide general procedures that will be followed during sample collection. The FSP provides specific instructions for sample collection based on the current understanding of site conditions at the Golden Butte mine.

The following procedures will be required during all sampling events:

- Sampling equipment will be decontaminated prior to and between sampling locations.
- Water quality meters will be rinsed with DI water before and after collecting measurements.
- Field information will be recorded on the sample collection form or groundwater purge record and/or in a field notebook. Samples will be logged on a chain of custody form. The samples will be kept secure in the custody of the sampler until they are transferred to the laboratory via overnight courier.
- Quality Assurance/Quality Control (QA/QC) samples will be collected and handled in a similar manner as the primary sample.

3.2.1 Surface Water

Surface water samples will be collected from each of the ROM and CO heap leach pad draindowns. These samples will be collected at the pads, prior to entering the vegetated channels. A water sample will also be collected from each of the three facility ponds (ROM pond, CO pond and barren pond). There are no natural streams at the site.

The techniques described in this section apply to collection of discharge water (i.e., draindown) from the heap leach pads and pond water samples. Surface water samples for laboratory analyses will be collected in accordance with SOP-1 and the specific information presented within this FSP.

3.2.1.1 Sample Collection

Surface water samples will be collected prior to recording field parameters or measuring flow. Only dedicated equipment will be used. The primary method for collecting surface water samples will be the grab-collection method. A swing sampler may be used to collect samples from the ponds. If a peristaltic pump is used, a portable battery powered unit should be incorporated such that it can be located directly adjacent to the sample location. The intake tubing can then be lowered into the desired sample location and the sample pumped directly into the sample container(s). Alternatively, a dedicated sample container can be used to collect the sample, which can then be transferred to the sample container(s). Samples requiring filtration will be field-filtered using a peristaltic pump or hand-held vacuum apparatus and 0.45 micron disposable cartridge-type filters. Dedicated disposable Teflon-lined tubing along with a short section of medical grade silicon tubing through the pump will be used to collect and filter samples when using a peristaltic pump.

3.2.1.2 Field Parameter Measurement

Field water quality parameters will be measured at surface water sampling locations. The field parameters to be measured include the following:

- Conductivity;
- Dissolved oxygen;
- pH;
- Temperature;
- Turbidity; and
- Flow/pond water level.

Field parameter measurements will occur in-situ whenever possible by lowering the decontaminated meter into the water. If an in-situ measurement is not possible, then the measurement will be made at the monitoring site using a decontaminated high-density polyethylene (HDPE) beaker to collect the sample for parameter measurement. Measurements will be recorded on the sample collection log and/or in the field notebook. Field meters will be used in accordance with the manufacturer's instruction. Meters will be calibrated, at a minimum, each day before use in the field.

3.2.1.3 Flow Measurements

Flow measurements will be recorded at all flowing surface water monitoring locations, which are currently limited to drainages from the heap leach pads. In addition, the pond water levels will be recorded on the sample collection forms and/or field logbook, when applicable. Staff gauges are located within the collection ponds at the site.

Volumetric methods will be used to measure flow in the heap leach pad drainages, as possible. The bucket and stop-watch technique is the typical method. Three consecutive measurements of flow volume, over similar time durations will be made. All flow in the drainages will be captured in the container during the period of measurement.

3.2.2 Groundwater

One groundwater sample will be collected from the East Water Well. According to current information, the well consists of 8-inch diameter steel casing with approximately 170 feet of standing water. This information will be verified in the field. The East Water Well is reported to have a pump within the well and for this reason it may not be possible to purge this well unless the pump can be made operational or removed. If this is the case, a grab groundwater sample may have to be collected with a bailer or similar device.

If possible, the well will be purged by pumping prior to sampling. Typically, one to three well-casing storage volumes are purged from a well prior to sampling. However, this may result in over 1200 gallons of purge water that would have to be discharged to the ground. Therefore the following procedure has been developed for determining the appropriate amount of well purging prior to collecting a sample. The water level and total well depth will be measured (or estimated) before purging and the well casing volume (CV) will be calculated as follows:

$$CV = 23.5\ r^2h$$

where:
CV = casing volume (gallons)
r = casing radius (feet)
h = total well depth -depth to water (feet)
23.5 = p x 7.48 (to convert from cubic feet to gallons)

The following criteria will then be used to determine the volume of purge water to be removed prior to sampling:

- If three casing volumes represents less than 400 gallons, the volume of purge water will equal three casing volumes (and/or when parameters stabilize).

- If three casing volumes is greater than 400 gallons, only one casing volume will be purged from the well prior to sampling (and/or when parameters stabilize).

All purge water will be land applied in a manner that does not result in erosion or impoundment. Wells will be allowed to recover to 80 percent of the initial water level before sample collection.

3.2.2.1 Sample Collection

Field parameters will be collected at the start of purging and at appropriate intervals based on the volume of water to be purged. Field parameters (pH, conductivity, temperature, DO and turbidity) will be recorded using a water quality meter. This will be accomplished by running a portion of the purge flow (approximately one to two gpm) through the bottom of a 5-gallon container or equivalent and letting the effluent spill over the top. The field meter will be placed in the bottom of the container near the influent flow. In this way representative DO measurements can be collected. Typically parameters will stabilize within one to three well volumes. Field parameter stabilization criteria include:

- pH – within 0.2 units
- conductivity – within 10 percent
- DO – within 10 percent
- temperature – within 0.5°Celsius

An attempt will be made to stabilize the parameters within the purging interval. If parameters do not stabilize by the end well purging, the sample will be collected and field parameters will be recorded. Purge water is not anticipated to be contaminated and will be discharged on the ground surface in a manner that does not result in erosion or impoundment.

3.2.2.2 Groundwater Level Measurement

Water level measurements will be recorded during groundwater sample collection. Water levels will be measured prior to purging and again before sampling. Measurements will be made using an electronic water level sounder and recorded on the sample collection form and/or field logbook. The location of the reference point being used will be noted and recorded (i.e. the height of the reference point above ground surface). Groundwater level measurements will be referenced to the top of casing or other appropriate reference. Total well depth will also be measured and recorded, when possible.

3.3 WATER QUALITY SAMPLING QA/QC

One equipment blank and one field duplicate will be collected from one of the surface water monitoring sites to assist in determining the usability of laboratory data. The equipment blank will be collected in a similar manner as the other sample collected at the site. Deionized water will be run through the pump, field filtered, and collected in the appropriate containers for analysis. The duplicate sample and equipment blank will be submitted blind to the laboratory as separate samples by using an alternate sample identification.

3.4 WATER ANALYSES

Surface water and groundwater samples will be analyzed for Nevada Profile II parameters and total cyanide. Table 3.1, *Nevada Profile II Parameters*, presents the water sample analytical list, methods and detection limits.

TABLE 3.1
NEVADA PROFILE II PARAMETERS

Parameter	Fraction	Method	Detection Limit	Units
GENERAL CHEMISTRY AND ANIONS				
Alkalinity		EPA 310.1	2.0	mg/l (as $CaCO_3$)
Chloride		EPA 325.2	1.0	mg/l
Fluoride		EPA 340.2	0.1	mg/l
Nitrate (NO3 + NO2 as N)		EPA 353.2	0.02	mg/l
pH		EPA 150.1	0.1	mg/l
Phosphorus (total as P)		EPA 365.1	0.01	mg/l
Sulfate		EPA 375.3	10.0	mg/l
WAD Cyanide		SM 45001-CN	0.01	mg/l
Total Dissolved Solids (TDS)		EPA 160.1	10	mg/l
Total Cyanide [1]		EPA 335.3	0.01	mg/l
CATIONS AND TRACE METALS				
Aluminum	Dissolved	EPA 6010B, ICP	0.03	mg/l
Antimony	Dissolved	EPA 6020, ICP-MS	0.0002	mg/l
Arsenic	Dissolved	EPA 6020, ICP-MS	0.0005	mg/l
Barium	Dissolved	EPA 6010B, ICP	0.003	mg/l
Beryllium	Dissolved	EPA 6020, ICP-MS	0.0001	mg/l
Bismuth	Dissolved	EPA 6010B, ICP	0.1	mg/l
Boron	Dissolved	EPA 6010B, ICP	0.001	mg/l
Cadmium	Dissolved	EPA 6020, ICP-MS	0.0001	mg/l
Calcium	Dissolved	EPA 6010B, ICP	0.2	mg/l
Chromium	Dissolved	EPA 6010B, ICP	0.01	mg/l
Cobalt	Dissolved	EPA 6010B, ICP	0.01	mg/l
Copper	Dissolved	EPA 6010B, ICP	0.01	mg/l
Gallium	Dissolved	EPA 6010B, ICP	0.1	mg/l
Iron	Dissolved	EPA 6010B, ICP	0.01	mg/l
Lead	Dissolved	EPA 6020, ICP-MS	0.0001	mg/l
Lithium	Dissolved	EPA 6010B, ICP	0.02	mg/l
Magnesium	Dissolved	EPA 6010B, ICP	0.2	mg/l
Manganese	Dissolved	EPA 6010B, ICP	0.005	mg/l
Mercury	Dissolved	EPA 7470,CVAA	0.0002	mg/l
Molybdenum	Dissolved	EPA 6010B, ICP	0.01	mg/l
Nickel	Dissolved	EPA 6010B, ICP	0.01	mg/l
Potassium	Dissolved	EPA 6010B, ICP	0.30	mg/l
Scandium	Dissolved	EPA 6010B, ICP		mg/l
Selenium	Dissolved	EPA 6020, ICP-MS	0.0015	mg/l
Silver	Dissolved	EPA 6010B, ICP	0.005	mg/l
Sodium	Dissolved	EPA 6010B, ICP	0.30	mg/l
Strontium	Dissolved	EPA 6010B, ICP	0.00005	mg/l
Thallium	Dissolved	EPA 6020, ICP-MS	0.00005	mg/l
Tin	Dissolved	EPA 6010B, ICP	0.1	mg/l
Titanium	Dissolved	EPA 6010B, ICP	0.005	mg/l
Vanadium	Dissolved	EPA 6010B, ICP	0.005	mg/l
Zinc	Dissolved	EPA 6010B, ICP	0.01	mg/l

1. Total cyanide is not a Nevada Profile II parameter, but will be included in the analyte list.

3.5 SAMPLE IDENTIFICATION AND LABELING

Water samples will be collected, preserved and stored as indicated in Table 3.2, *Water Sample Control and Preservation*.

TABLE 3.2 WATER SAMPLE CONTROL AND PRESERVATION				
Parameter		Maximum Holding Time	Storage Conditions	Filtration/Preservatives
TDS		28 days	4°C	Filtered/none
Sulfate, Chloride, Fluoride		28 days	4°C	Filtered/none
Metals	Total	6 months	4°C	Unfiltered/HNO_3 to pH < 2
	Dissolved	6 months	4°C	Filtered/HNO_3 to pH < 2
Phosphorus, Nitrate/Nitrite		28 days	4°C	Unfiltered/ H_2SO_4
Total CN, WAD CN		28 days	4°C	Unfiltered/NaOH
Alkalinity and pH		14 days	4°C	Unfiltered/none

Samples will be labeled in the field based on the following principles:

	Example
• Date	071502
• Site Name	WW
• Sample Number	01 (normal sample)
	02 (field duplicate)
	03 (equipment blank)

The sites will be designated as follows:

- East Water Well EW
- ROM Draindown RD
- Crushed Ore Draindown CD
- ROM Pond RP
- CO Pond CP
- Barren Pond BP

Therefore, a groundwater sample collected from the East Water Well on October 30, 2002, will be designated as 103002EW01.

A summary of water quality sample quantities and locations proposed for the current scope of work is provided below in Table 3.3, *Water Sampling Summary*.

TABLE 3.3
WATER SAMPLING SUMMARY

Location	Quantity	Parameters
Leach Pad Draindown (ROM, CO)	2	Field Parameters Flow Nevada Profile II Parameters (including total cyanide)
East Water Well	1	Field Parameters Water Level Nevada Profile II Parameters (including total cyanide)
Ponds (ROM, CO, Barren)	3	Field Parameters Water Level Nevada Profile II Parameters (including total cyanide)
QA/QC (surface water) (equipment blank and field duplicate)	2	Field Parameters (field duplicate only) Nevada Profile II Parameters (metals only for equipment blank)

4.0 SOIL MINE MATERIALS SAMPLING

Soil and mine material samples will be collected from potential borrow area(s), from the leach pads, and from the waste rock pile. Soils and mine materials will be tested for agronomic, geotechnical, geochemical, hydraulic parameters and total metals analyses, as required for characterization and to support development of the Final Closure Plan. Lists of these test parameters and analyses are presented in Tables 4.1 through 4.5, below. Sampling and analysis details for each area are discussed in the following sections.

TABLE 4.1
AGRONOMIC TEST PARAMETERS

Parameter	Units	Parameter	Units
Soil pH	s.u.	Bicarbonate phosphorus	ppm
Electrical conductivity	umhos/cm	Exchangeable potassium	ppm
Organic matter	ppm	Exchangeable magnesium	ppm
Free lime	--	Exchangeable calcium	ppm
Nitrate-N	ppm	Exchangeable and soluble sodium	ppm
Available nitrogen	lbs/A	Sodium Adsorption Ratio	ppm
Sulfate-Sulfur	ppm		

TABLE 4.2
GEOTECHNICAL TEST PARAMETERS

Test	Method
Grain Size Analysis (including hydrometer)	ASTM D421 and D422

TABLE 4.3
GEOCHEMICAL ANALYSES

Test	Parameters
Acid-Base Accounting (ABA)	sulfide-S, Acid Neutralization Potential (ANP), Acid Generating Potential (AGP), Net Neutralization Potential (NNP)
NWMP	Nevada II Profile Parameters and Total Cyanide
Paste pH	Paste pH

TABLE 4.4
HYDRAULIC TEST PARAMETERS

Initial Moisture Content	Moisture Characteristic Curve
Dry Bulk Density	Saturated Hydraulic Conductivity
Total Porosity	Calculated Unsaturated Hydraulic Conductivity

TABLE 4.5 TOTAL METALS ANALYSES				
Parameter	**Fraction**	**Method**	**Detection Limit**	**Units**
Antimony	Total	EPA 6020, ICP-MS	0.02	mg/kg
Arsenic	Total	EPA 6010B, ICP	0.1	mg/kg
Cadmium	Total	EPA 6010B, ICP	0.05	mg/kg
Copper	Total	EPA 6010B, ICP	0.1	mg/kg
Lead	Total	EPA 6010B, ICP	0.1	mg/kg
Manganese	Total	EPA 6010B, ICP	0.1	mg/kg
Mercury	Total	EPA 7470, CVAA	0.02	mg/kg
Nickel	Total	EPA 6010B, ICP	0.1	mg/kg
Selenium	Total	EPA 6010B, ICP	0.2	mg/kg
Silver	Total	EPA 6010B, ICP	0.05	mg/kg
Zinc	Total	EPA 6010B, ICP	0.1	mg/kg

4.1 BORROW SOURCE DETERMINATION

Previous data indicate that a soil cover with good water holding characteristics will be needed to cover the heap leach pads to prevent infiltration into the heap material. With limited available topsoil at the site, borrow soil will be needed to supplement existing topsoil for reclamation of the heap leach pads and possibly the waste rock disposal area. Soil maps and descriptions have been received from BLM and will be used to facilitate the borrow source investigation. Borrow areas will be investigated and sampled at the discretion of the field engineer. It is estimated that three (3) samples will be collected and analyzed for potential use as borrow material.

Backhoe test pits will be excavated in potential borrow areas to determine the available volume and suitability of soil for revegetation. The test pits will be excavated to a depth of approximately 4 feet and one representative, composite sample will be collected from each potential source. The samples will be analyzed for the following parameters/analyses:

- Agronomic Testing Parameters (Table 4.1);
- Geotechnical Testing Parameters (Table 4.2);
- Hydraulic Testing Parameters (Table 4.4); and
- Total Metals Analyses (Table 4.5).

Hydraulic properties of the sample will be determined by testing for saturated hydraulic conductivity, initial moisture content, dry bulk density, calculated total porosity, and soil moisture characteristic curve (seven points). These data will be used to calculate the unsaturated hydraulic conductivity function.

4.2 LEACH PAD CHARACTERIZATION

One representative surface sample will be taken from the top 0 to 24 inches from both the crushed ore and ROM pads to determine the geochemical, geotechnical, hydraulic and agronomic properties of the material. One representative heap leach pad sample will be selected for hydraulic property determination. Hydraulic properties of the samples will be determined by testing for saturated hydraulic conductivity, initial volumetric water content, dry bulk density, calculated total porosity, moisture characteristic and calculated unsaturated hydraulic conductivity. Due to the wide variation in the coarseness of the material on the run of mine pad, a range of hydraulic parameters may have to be extrapolated from modified laboratory procedures.

Geochemical testing will include paste pH and acid-base accounting (ABA), consisting of analysis for acid neutralization potential (ANP) and acid generation potential (AGP). Acid-base accounting is designed to measure the long-term potential of mine materials to generate acid based on a comparison of the ANP and AGP. Both potentials are typically expressed as an equivalent weight of calcium carbonate so that a direct comparison between the values can be made. AGP will be determined based on sulfide content and will be expressed as an equivalent weight of calcium carbonate by assuming that 31.25 tons of calcium carbonate are required to neutralize 1,000 tons of material that contains 1% sulfur by weight. This conversion is based on ideal chemical reactions and assumes that the sulfide in the material is completely converted to acid. Sulfide content will be determined by using EPA 600/2-78-054 3.2.6. Neutralization potential will be determined by adding a pre-determined amount of acid to a sample and titrating back to a reference pH to determined the amount of acid consumed. ANP will be determined using EPA 600/2-89-054 3.2.3. The net neutralizing potential and the ratio of neutralizing potential to acid-generation potential will be compared with screening values to determine acid production potential.

Geochemical testing of these materials will also consist of leachate analysis using the Meteoric Water Mobility Procedure (MWMP). The MWMP test was developed by the State of Nevada in 1995 to assess short-term leaching of mine materials. The procedure will evaluate the dissolution and mobility of solutes from mine material by meteoric water. Approximately 5 kg of waste rock material will be crushed to a grain size of less than 5 cm and will be leached in a column. The sample will be leached for 24 to 48 hours at a solid/liquid ratio of 1:1 using an extraction fluid of laboratory-grade, deionized water adjusted with nitric and sulfuric acid to a pH between 5.2 and 5.6. Leachate will be collected, filtered and analyzed for the Nevada Profile II constituents (including total cyanide) (Table 3.1).

Tests that will be performed on the crushed ore and run-of-mine heap leach pad materials are:

- Agronomic Testing Parameters (Table 4.1);
- Geotechnical Testing Parameters (Table 4.2);
- Geochemical Analyses (Table 4.3);
- Hydraulic Testing Parameters (Table 4.4); and
- Total Metals Analyses (Table 4.5).

4.3 WASTE ROCK EVALUATION

Previous reclamation activities performed on waste rock included re-contouring and seeding. Currently there is established vegetation on approximately 60 percent the pile. Revegetation may be limited by acid generation or lack of fine material.

The current extent of the acid generation problem on the waste rock pile will be determined through surface pH mapping using the field paste pH test. The paste pH test will involve crushing approximately 10 grams of sample to a minus 100 sieve and adding five milliliters of deionized water resulting in a paste of approximately 66% solids. After mixing the paste thoroughly, the pH will be measured using a standard pH electrode and meter, and the value will be reported to the nearest tenth of a standard unit. Sample sites will be biased towards sites with potential sulfide oxidation or limited vegetation (i.e., barren areas). Several samples will also be collected from vegetated areas for comparison. It is estimated that approximately 50 samples will be analyzed in the field for paste pH. Concurrent with the paste pH testing, a surficial map of the waste rock area will be generated to delineate vegetated and barren areas, noting whether barren areas are a result of acidic soils (based on pH testing) or lack of fine material (based on visual inspection).

Based on the outcome of the field reconnaissance and pH survey, two composite samples of the waste rock material will be collected to represent the acid-impacted (barren) and unimpacted (vegetated) areas, respectively. These samples will be tested for the following parameters/analytes:

- Agronomic Testing Parameters (Table 4.1);
- Geochemical Analyses (Table 4.3); and
- Total Metals Analyses (Table 4.5).

In addition, a field spring survey will be conducted around the perimeters of the waste rock area to determine whether any springs are emanating from the base of the waste rock pile. If any springs are discovered, photographs will be taken and field parameters (temperature, pH, conductivity and dissolved oxygen) will be measured and documented in the field notebook.

5.0 TOTAL MINE RECLAMATION COST ESTIMATE

A cost estimate will be developed on a component basis such that reclamation tasks can be prioritized based on available bond money. The following components will be included in the cost estimate within the Final Closure Plan:

- Methods identified for stabilization of heap leach pads and waste rock including recontouring and revegetation
- Characterize pond sludge leachate using MWMP for Nevada II Profile parameters
- Analyze pond sludge leachate using Toxicity Characteristic Leaching Procedure (TCLP) analysis of required metals for disposal requirements
- Bury pond liners and reconfigure ponds
- Develop cover for heap leach pads
- Break concrete foundations and bury on site
- Removal of site debris
- Recontouring of haul roads
- Placement of growth medium on reclaimed sites
- Cost of seeding all reclaimed sites
- Long-term monitoring
- Long-term handling of draindown fluids

The components of the cost estimate are discussed below.

5.1 POND SLUDGE CHARACTERIZATION

The mine reclamation cost estimate will include pond sludge sampling and characterization using TCLP and MWMP analyses. Costs of sludge characterization will include sampling and sample analysis.

5.2 POND RECLAMATION

The pregnant and barren ponds will be reclaimed by cutting and folding the liners inward and burying them in place. Material from the pond embankments will be used to bury the liners, utilizing a balanced cut and fill to the extent possible. Costs associated with pond reclamation will include sludge removal (if necessary), removal of the liners, embankment regrading, and final contouring. If necessary, costs for borrow soil excavation and placement will be included. A long-term solution for handling heap pad draindown will also be developed.

5.3 FOUNDATION AND DEBRIS REMOVAL

Concrete foundations will be broken up and buried in place. Reclamation costs will include demolition and final contouring. Site debris will be removed and transported to a designated landfill. Costs of removal will include loading and transportation.

5.4 LEACH PAD AND WASTE ROCK PILE RECONTOURING

A regrading plan for the waste rock pile and heap leach pads will be developed based on the results of the testing presented within this Work Plan. Once the regrading plan is developed, costs will be based on quantities to recontour the piles to the design specifications presented in the plan.

5.5 HAUL ROAD RECONTOURING

Haul road recontouring will involve ripping the existing surfaces and, where possible, regrading the soil using a balanced cut and fill. The estimated cost of haul road reclamation will be based on a total footage of haul roads to be reclaimed.

5.6 PLACEMENT OF GROWTH MEDIUM AND REVEGETATION

Areas selected for growth medium placement will have topsoil and/or borrow soil placed as required by the geochemical test results. Costs associated with soil placement will include excavation of the soil from the borrow area, haulage to the reclamation site, regrading and final contouring. Revegetation costs for each reclaimed area will include the material, placement, and incorporation costs of amendments, seed, and mulch. Revegetation will take place on the waste rock pile, leach pads, haul roads, borrow area and reclaimed ponds.

5.7 DIRECT AND INDIRECT COSTS

Direct costs will be determined by multiplying the calculated quantities for work activities by representative unit rates. Indirect costs will include mobilization, demobilization, jobsite overhead and contingency will be taken as a fixed percentage of the direct costs. MWH's database of unit rates for mine reclamation, as well as other standard estimating resources, will be used to determine representative unit rates for each activity.

5.8 LONG-TERM MONITORING

Long-term monitoring of the site will include bi-annual inspections of reclaimed areas, with inspections being held in the spring after runoff and again in the fall before the onset of winter. During the inspections, revegetated areas will be inspected for vegetation success and the waste rock pile and leach pads will be checked for erosion. Monitoring costs for annual site visits and report preparation will be estimated on an annual basis. The net present value of the long-term monitoring will be calculated based on a defined period and interest rate to include as a line item in the cost estimate.

APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

GOLDEN BUTTE MINE SITE INVESTIGATION
USACE CONTRACT NO. DACW05-00-D-0021

October 2002

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1.0 QUALITY ASSURANCE PROJECT PLAN

This QAPP documents project management and organization, identifies the procedures used to assure the accuracy, precision and representativeness of the data collected and assures the procedures provided in the FSP are implemented so that the project DQOs are achieved. The QAPP presents an overall description of the methods, responsibilities and procedures associated with the field charactization activities at the Golden Butte Mine near Ely, Nevada. Accordingly, this QAPP reflects MWH's current corporate standards and procedures for the implementation of these investigations, appropriate regulatory requirements and methods that have developed through experience on similar environmental programs. It is the responsibility of all project personnel either performing or overseeing sampling and analysis activities to adhere to the requirements of this QAPP and supporting project-specific documents.

1.1 PROGRAM MANAGEMENT

1.1.1 Project Organization

Effective project management is key to implementation of the sampling and analysis program. It provides all parties involved with a clear understanding of their role in the investigation and provides the lines of authority and reporting for the project. Key positions and associated responsibilities are outlined below.

<u>Bureau of Land Management Project Manager – Bill Wilson</u>
- Review and approve work plan and deliverables
- Review project technical and data reports
- Provide project oversight

<u>United States Army Corps of Engineers Project Manager – B.J. Bailey</u>
- Assure delivery of data and project deliverable to BLM
- Issue and oversee contractual issues
- Review project technical and data reports
- Provide project oversight

<u>MWH Technical Manager – David Ellerbroek</u>
- Provide oversight of all technical deliverables
- Implement necessary actions and adjustments to accomplish project objectives

<u>MWH Project Quality Assurance Manager – Kurt Condie</u>
- Work closely with the Technical Manager to assure that data are available on time
- Assure that the appropriate field QA samples are collected per project SOPs
- Receive laboratory deliverables and pertinent field data
- Coordinate and oversee electronic data management system

<u>MWH Field Coordinator – John Redmond</u>
- Assure sampling events are completed and all necessary data are collected
- Verify QA procedures are followed during sample collection
- Report difficulties/complications in sample collection to Technical Manager
- Assure chain-of-custody forms and field books are filled out properly

Analytical Laboratory(s)

- Responsible for off-site analysis of samples
- Deliver analytical results in a timely manner
- Calibrate and maintain laboratory equipment
- Conduct internal QA/QC procedures
- Notify QA Manager when problems occur
- Assure data and QA information are properly recorded
- Assure all custody records are properly completed and handled

1.1.2 Special Training Requirements/Certification

All personnel who enter an abandoned mine site must recognize and understand the potential hazards to health and safety associated with the site. Employees working on sites exposed to hazardous substances, health hazards, or safety hazards; their supervisors; and management responsible for the site will, at all time of assignment to the field, meet at a minimum the Occupational Safety and Health Administration (OSHA) hazardous waste site workers 40-hour training requirement. Additional training requirements specified in the Health and Safety Plan (Appendix C) will be completed as necessary. In addition, personnel responsible for operating mechanical equipment, including pumps, generators, and mixing equipment, will receive the necessary operating instruction on that equipment. Sampling personnel will be trained in the of use industry-standard practices. A qualified geologist or engineer will provide sampling oversight.

1.1.3 Problem Definition and Background

Background information for the Golden Butte Mine project and a description of the problems requiring analytical sampling are provided in Section 1.0 of the Work Plan.

1.1.4 Project Description

Field monitoring and sampling will be conducted to support the field investigation and development of a Final Closure Plan. The purpose of the field monitoring and sampling will be to determine the current site conditions as they relate to stabilization of potential mine components and water quality. A reclamation plan will be developed based on results from the field investigations and implemented as part of the Final Closure Plan. Descriptions of the project and investigative activities to be performed are provided in Section 4.0 of the Work Plan.

1.1.5 Criteria for Measurement Data

MWH will utilize a NDEP certified laboratory(s) or equivalent to analyze samples collected at the Golden Butte Mine. The laboratory and its staff have the responsibility to process all samples submitted according to the specific protocols for sample custody, holding times, analysis and associated laboratory quality assurance. Designated laboratory personnel will maintain contact with the Project QA Manager to assure that internal laboratory DQOs are achieved. Laboratory DQOs are defined in terms of accuracy and precision. Accuracy and precision will be assessed through the use of field quality assurance samples and consistent laboratory practices.

Table B.1, *Summary of Analytical Schedule*, presents sampling location, test matrix, test parameters, number of samples including Quality Assurance/Quality Control (QA/QC) samples and reference to an analyte list.

Table B.2, *Sample Requirements*, presents analytical methods, container type, preservation of media, minimum sample volune, and maximum holding time.

TABLE B.1 SUMMARY OF ANALYTICL SCHEDULE GOLDEN BUTTE MINE, NEVADA						
Location	**Matrix**	**Test Parameters**	**Total Estimated Number of Samples**	**Field Duplicates**	**MS/MSD**	**Reference**
Water Quaility Data						
Heap Leach Pad Drainages	water	Nevada Profile II and total cyanide/ Field Parameters	2	1		FSP, Table 3.1
Groundwater Well		Nevada Profile II and total cyanide/ Field Parameters	1			FSP, Table 3.1
Ponds		Nevada Profile II and total cyanide/ Field Parameters	3			FSP, Table 3.1
QA/QC Sample (Equipment Blank)		Nevada Profile II and total cyanide (Metals Only)	1			FSP, Table 3.1
Borrow Source						
Test pits (3)	soil	Argonomic Parameters	3			FSP, Table 4.1
		Geotechnical Parameters	3			FSP, Table 4.2
		Hydraulic Properties	3			FSP, Table 4.4
		11 Metals (Ag, As, Cd, Cu, Hg, Mn, Ni, Pb, Sb, Se, and Zn)	3		1	FSP, Table 4.5
Leach Pad						
ROM leach pad	rock	Argonomic Parameters	1			FSP, Table 4.1
		Geotechnical Parameters	1			FSP, Table 4.2
		Geochemical (ABA, MWMP, Paste pH)	1			FSP, Table 4.3
		Hydraulic Properties	1			FSP, Table 4.4
		11 Metals (Ag, As, Cd, Cu, Hg, Mn, Ni, Pb, Sb, Se, and Zn)	1			FSP, Table 4.5
Crushed ore leach pad	rock	Argonomic Parameters	1			FSP, Table 4.1
		Geotechnical Parameters	1			FSP, Table 4.2
		Geochemical (ABA, MWMP, Paste pH)	1			FSP, Table 4.3
		Hydraulic Properties	1			FSP, Table 4.4
		11 Metals (Ag, As, Cd, Cu, Hg, Mn, Ni, Pb, Sb, Se, and Zn)	1			FSP, Table 4.5
Waste Rock						
Waste rock pile (vegetated/barren)	rock	Argonomic Parameters	2			FSP, Table 4.1
		Geochemical (ABA, MWMP, Paste pH)	2			FSP, Table 4.3
		11 Metals (Ag, As, Cd, Cu, Hg, Mn, Ni, Pb, Sb, Se, and Zn)	2			FSP, Table 4.5

Notes:
FSP - Field Sampling Plan
MWMP - Meteoric Water Mobility Procedure
QA/QC - Quality Assurance / Quality Control
ROM - Run of mine

TABLE B.2
REQUIREMENTS FOR SAMPLING CONTAINERS
GOLDEN BUTTE MINE, NEVADA

	Matrix	Container Type	Minimum Sample Volume	Preservation	Maximum Holding Time
Argonomics Analysis - pH, electric conductivity - Free lime - Exchangeable (plus soluble) sodium percentage - Organic matter - Nitrate-nitrogen and estimated available nitrogen - Phosphorous, potassium, calcium, magnesium, and sodium - written recommendation	Soil	Glass jar or plastic bag	16 oz	None	NA
Metals (Sb, As, Cd, Cu, Pb, Mn, Hg, Ni, Se, Ag, Zn) - Method SW6010, 6020, 7470	Soil	Glass jar or plastic bag	100 g	None	mercury - 28 day others - 6 months
MWMP	Soil	5-gallon bucket	5 kg	None	NA
Nevada Profile II	Water	Various polyethylene bottles	Filtered: - 250 mL - 125 mL Unfiltered: - 500 mL - 250 mL - 500 mL -500 mL	Filtered: - unpreserved - HNO_3 Unfiltered: - unpreserved - HNO_3 - NaOH -H_2SO_4	NA
Soil pH	Soil	Glass jar or plastic bag	8 oz	None	NA
Geotechnical Classification	Soil	Glass jar or plastic bag	5 lbs	None	NA
Hydraulic Properties - Sample prep - Saturated hydraulic conductive - Initial volumetric water content - Dry bulk density - Calculated total porosity - Moisture charateristic (7 pts) - Calculated unsaturated hydraulic conductivity	Soil	Glass jar or plastic bag	5 lbs	None	NA

g - gram
kg - kilogram
lbs - pounds
mL - milliliter
oz - ounce
HNO_3 - nitric acid
MWMP - Meteoric Water Mobility Procedure
NaOH - sodium hydroxide
NA - Not applicable

Table B.3, *Water Monitoring Field Parameters*, lists the measurement performance criteria for field water quality monitoring.

TABLE B.3
WATER MONITORING FIELD PARAMETERS
GOLDEN BUTTE MINE, NEVADA

Parameter	Method	Detection Limit
Conductivity	EPA 120.1	1.0 µS/cm
Dissolved Oxygen	EPA 360.1	0.1 mg/L
pH	EPA 150.1	0.1 units
Temperature	Standard Methods 212	0.1 °C
Turbidity	Standard Methods 2130B	0.1 NTU
Flow	Volumetric Flow	NA
Water Elevation	ASTM Method	NA

NA = non applicable

1.1.6 Data Quality Objectives

Data quality objectives (DQOs) are a series of statements that define the type and quality of samples that will be collected during field work, clarify the objectives of the sampling effort and specify acceptable limits of uncertainty. DQOs are quantitative and qualitative statements that specify the quality of the data required to support decisions during the project. The DQOs were developed following the guidance contained in the document *USEPA Guidance for the DQO Process*, USEPA QA/G-4 (USEPA/600R-96/055).

Project objectives have dictated the sampling and analytical methods and QA/QC procedures that will be followed. The DQO approach was developed by the USEPA as a tool to aid planning and decision-making related to the data collection. A primary objective of this QAPP is to ensure that the collected data are of sufficient quality to support remedial decision-making, including development of the Final Closure Plan per NDEP guidance. The seven-step process for developing DQOs and their remedies is presented in Table B.4, *Data Quality Objectives*.

1.2 MEASUREMENT/DATA ACQUISITION

1.2.1 Sample Handling and Custody Requirements

Sample handling and chain-of-custody procedures will be strictly adhered to during sample collection, transportation and laboratory handling to assure the identity of the samples. Improper sample and data handling and inadequate chain-of-custody procedures affect the credibility and acceptability of analytical results, regardless of their accuracy or precision.

All samples will be appropriately labeled with pre-prepared labels. Each label will include the job number and project name, time and date of collection, sample depth, sample identification number, preservative (if applicable), analyses to be performed, and the initials of the sampler. The chain-of-custody record (COCR) will be initiated by the field sampling personnel upon collection of a sample and will accompany each shipping container. The sampling personnel will retain a copy of the COCR and send the original with the sample shipment.

TABLE B.4
DATA QUALITY OBJECTIVES

Task	DQO Step	Investigation Statement	Work Plan Reference
Water Quality Sampling	State the Problem	Meteroic waters, after coming into contact with mine materials may contain concentrations of dissolved metals and other constituents of potential concern that could potentially affect water resources.	Section 4.2
	Identify the Decision	One representative water quality sample will be collected from each of the two existing wells and the spring to use as background analysis. One water quality sample will be collected from draindown from each heap pad to help quantify the potential to affect water resources.	
	Identify Inputs to the Decision	Combine the obtained data with historical data from the files to determine trends and contaminants of potential concern. Compare results to drinking water and livestock water consumption standards. Laboratory results will be compared to internal laboratory control sample criteria, duplicates and field blanks to determine if data are consistent and usable.	
	Define the Study Boundaries	Study boundaries are the sample location of the spring, the two existing wells and the inlets to the two pregnant ponds.	
	Develop a Decision Rule	If no water is available at the selected sampling locations, then reconsider if a representative sample can be collected elsewhere.	
	Specify the Limits on Decision Error	Limits on analytical error are the internal laboratory DQOs including control limits for MS/MSD and LCS percent recovery, surrogate percent recovery, and detection limits.	
	Optimize the Design	By sampling the locations only once, sufficient data are expected to be generated to meet the DQOs.	
Borrow Source Determination	State the Problem	To complete reclamation activities at the Golden Butte mine site, additional soil borrow material will be required.	Section 4.3
	Identify the Decision	Test pits will be dug, logged by a qualified field technician, and grab samples will be collected. One representative soil sample will be submitted for laboratory testing.	
	Identify Inputs to the Decision	Data will be utilized to determine the usability of the area as a source of soil. Analytical laboratory results will be compared to internal laboratory control sample criteria to determine if data are consistent and usable.	
	Define the Study Boundaries	The study boundaries are to be determined by studying soil maps, data from Alta Gold's borrow pit and solution discharge test trenches. Possible locations will be trenched at in the field until a source is determined.	
	Develop a Decision Rule	The preferred borrow are will be determined by considering the volume of available soil, the haul distance to the heap pads, the type of soil, the types of vegetation existing in the area and the relative location to an established road.	

TABLE B.4 (CONT.) DATE QUALITY OBJECTIVES			
Task	**DQO Step**	**Investigation Statement**	**Work Plan Reference**
Borrow Source Determination (cont.)	Specify the Limits on Decision Error	Limits on decision errors cannot be assessed for qualitative decisions that rely on the professional judgement of the field technician. Limits on analytical error are the internal laboratory DQOs.	Section 4.3
	Optimize the Decision	By collecting one sample at the preferred borrow source, sufficient data are expected to be generated to meet the DQOs.	
Leach Pad Characterization	State the Problem	Two heap leach pads need to be reclaimed.	Section 4.4
	Identify the Decision	One composite, representative sample of material from the top 0-24 inches of the crushed ore pad and the run-of-mine heap leach pad will be collected to characterize geotechnical and geochemical properties.	
	Identify Inputs to the Decision	Data will be utilized to determine the suitability of the leach pads to grow vegetation and the potential to mobilize contaminants. Analytical laboratory results will be compared to internal laboratory control sample criteria to determine if data are consistent and usable.	
	Define the Study Boundaries	The study boundaries will be limited to the two heap pads.	
	Develop a Decision Rule	If a wide variation in the coarseness of the rock material is seen, more than one composite sample will be analyzed.	
	Specify the Limits on Decision Error	Limits on decision errors cannot be assessed for qualitative decisions that rely on the professional judgement of the field technician. Limits on analytical error are the internal laboratory DQOs including control limits for MS/MSD and LCS percent recovery, surrogate percent recovery and detection limits.	
	Optimize the Design	The appropriate numbers of samples will be collected depending on the variation in the coarseness of rock. Therefore, sufficient data are expected to be generated to meet the DQOs.	
Waste Rock Evaluation	State the Problem	Acid generation is currently keeping some areas from being reclaimed.	Section 4.5
	Identify the Decision	A paste pH surface mapping program will be completed and one composite, representative sample of material will be used to determine potential environmental impacts of the acid generating areas.	
	Identify Inputs to the Decision	Data will be utilized to determine the suitability of the waste rock to grow vegetation. Analytical laboratory results will be compared to internal laboratory control sample criteria to determine if data are consistent and usable.	

TABLE B.4 (CONT.) DATE QUALITY OBJECTIVES			
Task	**DQO Step**	**Investigation Statement**	**Work Plan Reference**
Waste Rock Evaluation (cont.)	Define the Study Boundaries	The study boundaries will be limited to the waste rock dumps.	Section 4.5
	Develop a Decision Rule	If different waste rock types are seen, more than one composite sample will be considered for analysis.	
	Specify the Limits on Decision Error	Limits on decision errors cannot be assessed for qualitative decisions that rely on the professional judgement of the field technician. Limits on analytical error are the internal laboratory DQOs including control limits for MS/MSD and LCS percent recovery, surrogate percent recovery and detection limits.	
	Optimize the Design	The appropriate numbers of samples will be collected depending on the variation in the waste rock. Therefore, sufficient data are expected to be generated to meet the DQOs.	

Samples will be properly packaged in shipping containers to ensure the integrity of the samples. Samples will be transported as soon as possible to the laboratory after sample collection. Shipping containers will be transported via courier or by priority next day delivery to the laboratory. Each shipment will be adequately tracked and documented and will arrive at the laboratory ready for analysis.

Each person who has the samples in his/her possession, including couriers (except Federal Express), will sign the COCR. Upon sample receipt at the laboratory, the cooler temperature will be recorded and the sample container integrity will be checked. Any deficiencies at the time of sample receipt at the laboratory will be documented on the cooler receipt form and the MWH QA Manager will be notified for necessary resolution.

1.2.2 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Instrument calibration is necessary to endure that the analytical systems are operating correctly and functioning at the proper sensitivity to meet PQLs. Calibration establishes the dynamic range of an instrument, establishes response factors to be used for quantitation, and demonstrates instrument sensitivity. All laboratory instruments will be calibrated in accordance with each laboratory's SOPs. Criteria for calibration are specific to the instrument and the analytical method. Field instruments will be calibrated daily or immediately before use per manufacturer's instructions.

1.2.3 Inspection Requirements for Supplies and Consumables

All purchased supplies and consumables that support field monitoring and sampling activities or that have a direct relationship to sample quality (e.g. sample containers, decontamination supplies, distilled/de-ionized water) will be inspected upon receipt. At a minimum this inspection will check:

1) Part number/physical description matches requisition
2) Supplies are intact and undamaged
3) All required components/documentation is included

Any non-conforming items will be documented and returned to the supplier for replacement or other action as necessary.

1.3 DATA VALIDATION AND USABILITY

1.3.1 Data Review and Verification Requirements

The contracted laboratories will be responsible for reviewing all analytical data generated under this contract to ensure that it meets the requirements of this QAPP. Each analyst reviews the quality of their work based on established protocols specified in laboratory SOPs, analytical method protocol, project-specific requirements and DQOs. The laboratory will provide analytical results in electronic and paper formats. At a minimum, data verification will include evaluation of sampling documentation, technical holding time, instrument calibration and tuning, field and lab blank sample analyses, method QC sample results, field duplicates and the presence of any elevated detection limits.

1.3.1.1 Laboratory Quality Control

Laboratory overall method performance shall be monitored by the inclusion of various internal QC checks that allow an evaluation of method control (batch QC), and the effect of the sample matrix on the data being generated (matrix-specific QC). Batch QC is based on the analysis of a LCS to generate accuracy (precision and bias) data and method blank data to assess the potential for cross-contamination. Matrix-specific QC will be based on the use of an actual environmental sample for precision and bias determinations from the analysis of MS, MSD, matrix duplicates and surrogate spikes. Laboratory QC will be based on the labs internal QA/QC plan and SOPs. Some QC procedures discussed in this section are not included in the current scope, but are provided to cover future sampling scenarios. Current field QC requirements for the project were presented in Table B.1 The overall quality objectives are to implement procedures for laboratory analysis and reporting of data that are indicative of the degree of quality consistent with their intended use.

Method Blank Samples

Method blanks are analyzed to assess background interference or contamination that exists in the analytical system that might lead to the reporting of elevated concentration levels or false positive data. The method blank is defined as an interference-free blank matrix similar to the sample matrix to which all reagents are added in the same volumes or proportions as used in sample preparation and carried through the complete sample preparation, cleanup, and determinative procedures. For aqueous analyses, analyte-free reagent water would typically be used. The results of the method blank analysis are evaluated, in conjunction with other QC information, to determine the acceptability of the data generated for that batch of samples. Sample results shall not be corrected for blank contamination.

In general, one method blank sample shall be analyzed for each analytical batch (one every 12 hours for GC/MS analyses). Contamination in method blanks (as well as reagent blanks, instrument blanks, extraction blanks for elutriations, initial calibration blanks, and continuing calibration blanks) above the MDL is not allowed. Data found to be associated with blanks containing target analytes at or above the MDL may be rejected with re-sampling and/or re-extraction and reanalysis at the expense of the laboratory. The USACE will evaluate the data based on the level detected in the associated samples. Chronic systematic method blank contamination will not be accepted.

Laboratory Control Samples

The LCS is analyzed to assess general method performance by the ability of the laboratory to successfully recover the target analytes from a control matrix. The LCS is similar in composition to the method blank. For aqueous analyses use analyte-free reagent water. For soil analyses, a purified solid matrix (e.g., Ottawa sand, sodium sulfate, or other purified solid) would typically be used. However, due to the difficulty in obtaining a solid matrix that is metals-free, analyte-free reagent water is taken through the appropriate digestion procedures for metals analyses. The LCS is spiked with all single-component target analytes (the complete target compound or analyte list) before it is carried through the preparation, cleanup, and determinative procedures. The laboratory will perform corrective action based on failure of any analyte in the spiking list. When samples are not subjected to a separate preparatory procedure (i.e., purge and trap VOC analyses), the continuing calibration verification (CCV) may be used as the LCS, provided the CCV acceptance limits are used for evaluation. The spiking levels for the LCS would normally be set at the project-specific action limits assuming that the low standard used for the initial calibration was below this limit. If the low standard used was at this limit or if the site action levels were unknown, then the spiking levels would be set between the low and mid-level standards. The results of the LCS are evaluated, in conjunction with other QC information, to determine the acceptability of the data generated for that batch of samples. The laboratory shall also maintain control charts, or tables for these samples to monitor the precision. The precision may be evaluated by comparing the results of the LCS from batch to batch, or by duplicate LCSs. Duplicate LCSs within the same batch are not required, but recommended by the USACE.

Matrix Spike

The MS is used to assess the performance of the method as applied to a particular project matrix. A MS is an environmental sample to which known concentrations of certain target analytes have been added before sample manipulation from the preparation, cleanup, and determinative procedures have been implemented. The entire target analyte list will be spiked within the MS. The laboratory will perform corrective action based on failure of any analyte in the spiking list. The spike concentrations of the target analytes would normally be set at the same level as the LCS. From the laboratory perspective, preparation batches require MS frequency at one per preparation batch. The merging of these MS frequencies is often difficult for the laboratory to implement. For instance, batches consisting of samples from multiple sites may require additional MSs to meet project requirements of evaluating the samples within the batch. For a MS from one site cannot be used to evaluate the matrix effects on samples from other sites. The results of the MS are evaluated, in conjunction with other QC information, to determine the effect of the matrix on the bias of the analysis. Sample results shall not be corrected for MS QC excursions.

Matrix Spike Duplicate

The MD or MSD is used to assess the performance of the method as applied to a particular matrix and to provide information on the homogeneity of the matrix. A MSD is a duplicate of the MS as previously described. A MD is an environmental sample that is either divided into two separate aliquots by the laboratory, or requires the submittal of an additional sample. When applicable, care should be taken to ensure that the sample is properly divided into homogeneous fractions. Both the MD and MSD are carried through the complete sample preparation, cleanup, and determinative procedures. The normal use of these QC samples would follow the same requirements as described for the MS. The MD is included with each preparation batch of samples processed where target analytes were expected to be present (e.g., inorganic methods). An MSD is included with each preparation batch of samples processed where target analytes were not expected to be present (e.g., organic methods). The results of the MD or MSD are evaluated, in conjunction with other QC information, to determine the effect of the matrix on the precision of the analysis.

Surrogate Standards

Surrogates are analyzed to assess the ability of the method to successfully recover these specific non-target compounds from an actual matrix. Surrogates are organic compounds that are similar to the compounds of interest in chemical behavior, but are not normally found in environmental samples. Surrogates to use are identified within the determinative methods. Other compounds may be chosen and used as surrogates, depending on the analysis requirements, whether they are representative of the compounds being analyzed, and whether they cover the chromatographic range of interest. These compounds should be spiked into all samples and accompanying QC samples requiring GC or GC/MS analysis prior to any sample manipulation. As a result, the surrogates are used in much the same way that MSs are used, but cannot replace the function of the MS. The results of the surrogates are evaluated, in conjunction with other QC information, to determine the effect of the matrix on the bias of the individual sample determinations. Control charts, or tables, shall be maintained for surrogates contained within the LCS or MB to monitor the accuracy of the method for each particular matrix. Sample results shall not be corrected for surrogate excursions.

1.3.1.2 Documentation and Records

MWH will store all important project-related records in a centralized and easily accessible project file. The project manager or designee will maintain the project file. The project file will include the following types of field records:

- Field data measurements
- Sample collection records
- COCRs
- QC sample records
- Field notes, which will include descriptions of any deviations from the QAPP and any difficulties encountered in maintenance or sample collection
- Data results from the analytical laboratories
- Laboratory data deliverables (hard copy and electronic)

All laboratory-related documentation and records will be controlled, distributed, stored and maintained by the contracted laboratories. The information and records to be included in project-specific data reporting packages, and the reporting format, are specified in the following sections.

1.3.1.3 Analytical/Statistical/Control Parameters

Precision

Precision refers to the distribution of a set of reported values about the mean, or the closeness of agreement between individual test results obtained under prescribed conditions. Precision reflects the random error and may be affected by systematic error. Precision also characterized the natural variation of the matrix and how the contamination exists or varies within that matrix. In order to assess matrix heterogeneity or sample handling procedures, field precision is commonly determined from field duplicates samples. In general, field duplicates (QC samples) will be collected at a frequency of one duplicate for each ten samples of a given matrix. The current field duplicate schedule was presented in Table B.1. The identity of QC samples shall be held blind to the Contract Laboratory until after analyses have been completed.

The relative percent difference for field and laboratory duplicates shall be calculated and used as a measure of precision, however only laboratory duplicates will be included in the quantitative assessment of completeness. Results of field duplicates will be described in qualitative assessment of completeness.

For environmental samples, laboratory precision is commonly determined from laboratory duplicate samples. Laboratory duplicates are defined as two aliquots obtained from the same sample which are extracted and analyzed for the purpose of determining matrix specific precision. In general, laboratory duplicates will be performed for all metals analyses at a rate of one in twenty (one for each batch up to a maximum of twenty). Precision for organic analyses may be determined by the analysis of Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples.

Laboratory duplicate samples not meeting QC criteria shall be re-extracted/reanalyzed once. (For organic analyses failure of different matrix spike compounds to meet QC criteria on successive runs shall constitute failure and satisfy the requirement for reanalysis.) Statistical measures of precision included RPD, standard deviation, or RSD.

Accuracy

Accuracy is the measure of the closeness of an observed value to the “true” value (e.g., theoretical or reference value). Accuracy includes a combination of random error and systematic error (bias) components that result from sampling and analytical operations.

Representativeness

Representativeness refers to the degree to which sample data accurately and precisely describe the characteristics of a population of samples, parameter variations at a sampling point, or environmental condition. Samples that are not properly collected or preserved (e.g., contaminant loss or addition) or are analyzed beyond acceptable holding times should not be considered to provide representative data. An assessment of represenativeness would include an evaluation of precision. The representativeness criterion is best satisfied in the laboratory by making certain that all subsamples taken from a given sample are representative of the sample as a whole. This would include sample pre-mixing/homogenizing prior to and during aliquotting procedures. Samples requiring volatiles analysis should not undergo any premixing or homogenization. Therefore, noting sampling characteristics in a case narrative may assist in the evaluation of data. Representativeness can be assessed by a review of the precision obtained form the field and laboratory duplicate samples. In this way, they provide both precision and representativeness information.

Comparability

Comparability is a qualitative objective of the data, expressing the confidence with which one data set can be compared with another. Sample data should be comparable for similar samples and sample conditions. Comparability is unknown unless precision and bias are provided. When this information is available, the data sets can be compared with confidence.

The laboratory shall make the necessary provisions to ensure the comparability of all data. These procedures include, but are not limited to, the use of standard approved methodologies, the use of standard units and report format, the use of calculations as referenced in the methodology for quantitation, and the use of standard measures of accuracy and precision for QC samples. All provisions to ensure data comparability shall be detailed in the QAPP.

Completeness

Completeness shall be evaluated qualitatively and quantitatively. The qualitative evaluation of completeness shall be determined as a function of all events contributing to the sampling event including items such as correct handling of chain of custody forms, etc. The quantitative description of completeness shall be defined as the percentage of measurements that are judged to be usable (i.e., which meet project-specific requirements) compared to the total number of measurements planned.

Sensitivity

The term sensitivity is used broadly here to describe the contract method detection, quantitation, and reporting limits established to meet the DQOs; and not limited to the definition which describes the capability of a method or instrument to discriminate between measurement responses. Several limits may be established to describe sensitivity requirements (i.e., instrument detection limits [IDL], method detection limits [MDL], sample quantitation limit [SQL], practical quantitation limits [PQL], contractor-required detection limits [CRDL], contract-required quantitation limits [CRQL], etc.). Current sensitivity requirements (MDLs) for this project are presented in the FSP.

1.3.2 Quality Control Responsibilities

All of the selected staff for this project have the qualifications and experience required for conducting their specific assignments. If staff changes are necessary during the execution of this work, resumes shall be submitted for new personnel, and a description of their responsibilities, in a technical memorandum to the USACE Project Manager. All MWH project personnel are responsible for identifying, reporting, and documenting any activities that could adversely affect the quality requirements set forth by the contract.

Each laboratory has a designated project manager for this project and shall provide direct interface with MWH personnel. As the Laboratory Project Manager, they are responsible for ensuring that all analytical data generated under this contract are reviewed prior to their release to MWH and the USACE Project Manager. They have sufficient authority to assure that samples submitted from the project site are received and processed in accordance with their MWH accepted quality management system.

1.3.3 Reconciliation with Data Quality Objectives

An assessment of data quality will be performed to determine whether data generated are consistent with the investigation objectives. If data are found to deviate significantly (several orders of magnitude) from previous analyses or surrounding conditions upon which the sampling program was based, the data may be qualified based on the validator's assessment of the usability of the data for the intended end uses.

1.4 CORRECTIVE ACTION

Corrective action is required when potential or existing conditions are identified that may have an adverse impact on data quality. Corrective action applies to both the field and laboratory procedures. In general, any member of the project team who identifies a condition adversely affecting quality can initiate corrective action. Written evidence (e.g. field or laboratory logbook) will document and identify the condition and explain the way it may affect data quality.

A well-defined and effective policy for correcting quality problems is critical to the success of a quality assurance program. While this QA program is designed to minimize problems, it must also identify and correct any problems that do exist. The corrective action system for this project will include:

- Identify the problem
- Identify cause of the problem
- Identify corrective actions to correct the problem
- Implement corrective actions
- Verify effectiveness of corrective actions in correcting the problem
- Document corrective action including:
  - Problem identified and cause
  - Corrective actions implemented
  - Effectiveness of corrective actions
  - Samples impacted by problem

Documentation of corrective actions will be included in the project file.

APPENDIX C

SITE SPECIFIC HEALTH AND SAFETY PLAN

GOLDEN BUTTE MINE SITE INVESTIGATION
USACE CONTRACT NO. DACW05-00-D-0021

October, 2002

STANDARD OPERATING PROCEDURE
HEALTH AND SAFETY PLAN

Approvals: **Date**:

______________________________ ______________________

MWH Health and Safety Officer

______________________________ ______________________

MWH Project Manager

SITE SPECIFIC HEALTH AND SAFETY PLAN

for the
Golden Butte Site Reclamation Project
Ely, Nevada

1.0 ITEMS 1.0 – 9.0 TO BE COMPLETED BY PROJECT MANAGER OR SITE SAFETY COORDINATOR:

PROJECT NAME: Golden Butte Site Reclamation Project

REQUESTED BY: David Ellerbroek

PROPOSED START-UP DATE: August 15, 2002

PROJECT/TASK NUMBER: 5030062.011809

REVISION NUMBER 1

Prepared by/Reviewed by Site Health and Safety Coordinator

Printed Name: Mike Ross

Signature____ Date____________________

Reviewed by Corporate Health and Safety Officer

Printed Name: Beth Darnell

Signature____ Date_____________________

Approved by Project Manager

Printed Name: David Ellerbroek

Signature____ Date____________________

2.0 PROJECT DESCRIPTION: The Golden Butte Mine site Work Plan consists of data collection activities associated with characterization of the site to develop the Final Closure Plan. The role of MWH at the site during reclamation activities will include project management, engineering design consultation, water and soil sampling and environmental monitoring.

3.0 LOCATION: The Golden Butte Mine is located in White Pine County, approximately 45 miles northwest of Ely, Nevada. The site is located on the western slope of the Cherry Creek Range in Butte Valley and accessed via State Highway 93.

4.0 FACILITY/WORK SITE DESCRIPTION: The Golden Butte Mine site consists of an open pit, a waste rock disposal area, two leach pads, ponds, and ancillary facilities.

5.0 PERSONNEL AND TASKS:

Project Manager: David Ellerbroek

Field Personnel: John Redmond, Construction Manager
Kurt Condie, Field Engineer
Mike Ross, Field Engineer

On-site Safety Coordinator: Mike Ross

All personnel will be required to have a site briefing prior to first entry onto site. This briefing will be conducted by the MWH Site Health and Safety Coordinator or Project Manager. Additionally, "tailgate" safety meetings will be conducted daily prior to any activities. All field personnel will be OSHA 40 hour health and safety trained.

All contractors to MWH, and their subcontractors, are required to have their own individual site-specific Health and Safety Plans, which will be reviewed and approved by the MWH Site Safety Coordinator prior to mobilization on site.

6.0 EMERGENCY RESPONSE

The on-site safety coordinator will have final authority for first response to on-site emergency situations. In the event that the on-site safety coordinator is not on site, and alternate coordinator will be designated with all applicable authority.

Upon arrival of the appropriate emergency response personnel, the site emergency coordinator shall defer all authority to emergency response personnel but will remain on the scene, if necessary, to provide any and all possible assistance. At the earliest opportunity, the site safety officer or the site emergency coordinator shall contact the MWH Project Manager or MWH Health and Safety Officer.

Project Manager:
David Ellerbroek **Phone (W) :** (970) 879-6260 **Phone (H) :** (970) 871-1906
Mobile Phone: (303) 638-2716

Health & Safety Officer:
Mike Ross **Phone (W) :** (970) 879-6260 **Phone (H) :** (970) 638-1088

Nearest Emergency Facility: William Bee Ririe Hospital

Location: 6 Steptoe Circle in downtown Ely.

Telephone: (775) 289-3612

Directions: Travel to Ely using State highway 93 (South). Turn left on 15th Street and travel one block to Avenue G. The hospital is on the right.

7.0 DETAILED WORK DESCRIPTION

The Golden Butte Mine Work Plan consists of sampling and characterization activities associated with preparation of the Final Closure Plan for the site. The role of MWH at the site during the site activities will include project management, soil and water sampling, engineering design conceptualization, and environmental monitoring and testing. The work will be conducted at various locations on the site including the leach pad, overflow pond, waste rock piles, and various springs.

Site activities will include the following tasks:

- Groundwater and surface water sampling;
- Borrow source investigation and sampling;
- Leach pad characterization;
- Evaluation of waste rock reclamation options; and,
- Soil sampling for total petroleum hydrocarbon (TPH) contamination;

A more detailed description of all sampling and characterization activities to be completed in August 2002 is presented in Section 4, Project Tasks.

8.0 CHEMICAL/RADIOLOGICAL HAZARD EVALUATION

Are chemicals or radiological hazards known or suspected at this site.

_X_ Yes - describe below ___ No

	Waste Media	Hazardous Characteristics
_X_	Airborne Contamination	__ Ignitable
_X_	Surface Contamination	_X_ Corrosive
_X_	Contaminated Soil (hydrocarbons)	__ Reactive
_X_	Contaminated Groundwater	__ Explosive
_X_	Contaminated Surface Water	_X_ Toxic (non-radiological)
_X_	Solid Waste (leach pad and waste Rock materials)	__ Radioactive
__	Liquid Waste	

Description:

PRIMARY HAZARDS (Rate: low, medium, high, extreme)								
Substance	**Inhalation of Gases/ Vapors**	**Inhalation of Dusts/Mists**	**Ingestion**	**Dermal Absorption of Solids/Liquids and or Skin Contamination**	**Dermal Absorption of Gases/Vapors**	**Corrosive / Irritant**	**Ignitability**	**Toxicity**
Tailings	N/A	MEDIUM	LOW	LOW	N/A	LOW	N/A	LOW
Low pH water (< 3.0 pH)	N/A	N/A	LOW	LOW	N/A	LOW	N/A	LOW

SUBSTANCE	Level D	Level C (APR) (1)	OSHA PEL (2)	ACGIH TLV (3)
Dust-(with metals or silica)	0-.05 mg/m^3	0.05-0.5 mg/m^3	0.05 mg/m^3	0.05 mg/m^3
Water	pH > 3.0	PH > 3.0		1.0 ppm

(1) APR—Air Purifying Respirator
(2) PEL—Permissible Exposure Limit
(3) ACGIH TLV—American Conference on Government Industrial Hygienists, Threshold Limit Value

9.0 PERSONAL PROTECTIVE EQUIPMENT

Location	Job Function/Task	Initial Level of Protection			
		A	B	C	D
Golden Butte Site	Soil Sampling, Site Characterization				X
Golden Butte Site	Groundwater and surface water sampling				X

List the specific protective equipment and material (where applicable) for each of the Levels of Protection identified above.

Level C (same as Level B with lower level respiratory protection)

_ Coveralls
_ Disposable nitrile
_ Chemical resistant clothing, gloves and boots
_ Long underwear
_ Ear Protection
_ Half or full face air purifying respirator with canister
_ Canister type: _____ HEPA, _________ (Other)
_ Hard hat, steel toed rubber boots, safety glasses
_ Inner latex gloves
_ Outer NBR (Nitrile Butyl Rubber) gloves
_ Tyvex if waste is dry. Polytyvek if wet. Saranex if PCB wastes.
_ Two-way radio communication

Level D

_X_ Coveralls (as required)
_X_ Standard work clothes
_X_ Hard hat
_X_ Safety boots
_X_ Safety glasses
_X_ Goggles (as needed during water sampling)
_X_ Acid resistant gloves (when sampling low pH water)
_X_ Safety vest (as required when around heavy equipment)
_X_ Ear protection
_X_ Dust mask (required during dusty conditions)

Note: Dust masks will be made available to all personnel for use as site conditions warrant.

NO CHANGES TO THE SPECIFIED LEVELS OF PROTECTION SHALL BE MADE WITHOUT THE KNOWLEDGE AND APPROVAL OF THE HEALTH AND SAFETY OFFICER AND THE PROJECT MANAGER.

10. ACTION LEVELS

Task personnel shall observe the following Action Levels:

Substance	Action Level	Specific Action
Acid Water Sample	pH < 3.0	Skin Protection – Chemical resistant gloves, chemical resistant safety glasses.
Air Quality – Total Suspended Particulate	High Level Dust and Visibility < 20[1] ft. Some Dusty Conditions	Stop Work; Disposable dust mask

11. CONFINED ENTRY PROCEDURES _X_ Not Applicable __ Applicable

Will this project require entry into any confined or partially confined space?

__ Yes - describe below _X_ No

It is not anticipated that any reclamation tasks will involve working in a confined space. If confined spaces are encountered work will be done in accordance with the subcontractor's HASP, as applicable.

12. CUTTING/WELDING PROCEDURES _X_ Not Applicable __ Applicable

Will any task involve use of a cutting torch or welding?

__ Yes - describe below _X_ No

Requirements

__ Relocate or Protect Combustibles
__ Wet Down or Cover Combustible Floor
__ Check Flammable Gas Concentrations (% LEL) in air
__ Cover Wall, Floor, Duct and Tank Openings
__ Provide Fire Extinguisher

13. OTHER POTENTIAL HAZARDS

__	Fire/Explosion	X	Trips, Slips, Falls
X	Temperature Stress	X	Trenching/Shoring
___	Electrical	X	Heavy Equipment/Vehicular Traffic
__	Gas (Sulfur, O_2 deficiencies)	___	Overhead Hazards
X	Unstable/Uneven Terrain	X	Machinery/Mechanical Equipment
___	Torch Cutting or Welding	X	Other - Describe below

Description:

- Site location is subject to hot and cold weather extremes. Cold exposure may increase with wind velocity. Weather conditions have the potential become extreme rather quickly (rain or snow). Cold weather and rain gear should be available at the site at all times. Site personnel should be aware of heat stroke potential, and monitor as appropriate during warm weather activities.

- Personnel need to be aware of unmarked hazards which may potentially cause slips, trips, and falls. These unmarked hazards may include unstable or uneven terrain, miscellaneous site debris, piping, cables, low profile concrete building foundations, etc.

- Heavy equipment will be used for soil sampling. Caution and an alert attitude should be used when near heavy equipment. Keep a safe distance at all times. Equipment should be approached only after it has stopped and after eye contact has been established with the operator. Personnel should also be aware of regular vehicular traffic. Site trucks and ATVs should always be parked outside of heavy equipment work areas.

- Trenching or excavation of test pits may be required during the borrow soil investigation. Under no circumstances should an open trench with vertical walls be entered without proper shoring if it is deeper than 4.0 feet.

An activity hazard analysis (AHA) of site sampling activities is presented in Table 1 at the end of this Health & Safety Plan.

14. PERSONAL MONITORING _X_ Not Applicable _ Applicable

_ Passive Dosimeter   _ Biological Monitoring   _ Personal Air Sampling   _ Other

Does this project require medical surveillance or biological monitoring procedures beyond the provisions of the routine medical surveillance program? ___ Yes _X_ No

If yes, describe below.

Description: N/A

15. PERSONAL DECONTAMINATION _X_ Not Applicable ___ Applicable

ON-SITE CONTROL _X_ Not Applicable ___ Applicable

At this time, contamination is not expected in any of the areas where construction is planned. Therefore, a Controlled Zone has not been established. If a Controlled Zone is established, personnel and equipment leaving the Controlled Zone shall proceed through the following decontamination stations and procedures from the decontamination zone (Decontamination area(s) designated for all decontamination activities, will be selected by MWH field supervisors):

A: Personnel Decontamination
(Procedure not required unless action level utilizes Level C PPE or higher.)

Station Procedure

1. Boot wash	Wash (scrub) and rinse steel toed rubber boots
2. Outer glove wash/drop	Wash and rinse outer rubber gloves
3. Respirator	Remove respirator - wash nightly

Emergency Decontamination Procedures:

If decontamination can be done: Wash, rinse and/or cut off protective clothing and equipment.

If decontamination cannot be done: Wrap victim in blankets, plastic or rubber to reduce contamination of other personnel. Alert emergency and off-site personnel to potential contamination; instruct them about specific decontamination procedures if necessary. Send along site personnel familiar with the incident.

The following decontamination equipment is required:

NONE

SANITATION REQUIREMENTS (May be clarified during future site visit.)

Potable water supply (portable water cooler) available on work site? _X_ Yes __ No

Portable toilets required on work site? _X_ Yes __ No

Temporary washing/shower facilities required at work site?
___ Yes If yes, describe below.
_X_ No If no, state location of existing facilities. Ely, Nevada

16. EMERGENCY PROCEDURES This section is to be posted in a prominent location on-site.

EMERGENCY RESPONSE

The on-site safety coordinator, Mike Ross, has final authority for first response to on-site emergency situations. In the event that the on-site safety coordinator is not available, an alternate coordinator will be designated with all applicable authority.

Nearest Emergency Facility: William Bee Ririe Hospital

Location: 6 steptoe Circle, in downtown Ely

Telephone: (775) 289-3612

Directions: Travel to Ely using State highway 93 (South). Turn left on 15th Street and travel one block to Avenue G. The hospital is on the right.

Upon arrival of the appropriate emergency response personnel, the site emergency coordinator shall defer all authority but shall remain on the scene, if necessary, to provide any and all possible assistance. At the earliest opportunity, the site safety officer or the site emergency coordinator shall contact the MWH Project Manager or Health and Safety Officer.

Project Manager:
David Ellerbroek **Phone (W) :** (970) 879-6260 **Phone (H) :** (970) 871-1906
Mobile Phone : (303) 638-2716

Health & Safety Officer:
Mike Ross **Phone (W) :** (970) 879-6260 **Phone (H) :** (970) 638-1088

On-site Communication Required? __ Yes _X_ No

On-site: N/A

Emergency Channel: N/A

Nearest Telephone: Mobile phone or public phone in Ely.

Mobile Telephone (site): Limited cellular service in area.

FIRE AND EXPLOSION

In the event of a fire or explosion, if the situation can be readily controlled with available resources without jeopardizing the health and safety of yourself, the public, or other site personnel, take immediate action to do so, otherwise:

1. Notify emergency personnel by calling 911
2. If possible, isolate the fire to prevent spreading.
3. Evacuate the area.

EXPOSURE

Site workers must notify the site Health and Safety Officer immediately in the event of any injury or any of the signs or symptoms of overexposure to heat or cold.

Designated Personnel Current in First Aid/CPR: (TBD)

REQUIRED EMERGENCY BACK-UP EQUIPMENT/NOTIFICATIONS:
(Located in back of field vehicle.)

_X_ Fire extinguisher
_X_ First aid kit, including eye wash
_X_ Portable phone
_X_ Radio
_X_ Flares
_X_ Water in field vehicles, including ample volume for possible rinsing
_X_ Hearing protection
_X_ Dust masks
_X_ Rain and cold weather gear
_X_ Buddy System – make sure someone else knows where you are and your schedule

17. FIELD PROCEDURES CHANGE AUTHORIZATION

Instruction Number to be changed:
Duration of Authorization Requested:

Date:

Description of Procedure Modification:

Justification:

Person Requesting Change:	**Verbal Authorization Received From:**
______________________________	______________________________
Name	Name
______________________________	______________________________
Title	Title
______________________________	______________________________
Signature Date	Approved By Date

(Signature of person named above to be obtained within 48 hours of verbal authorization)

18. SAFETY BRIEFING

The following safety briefing will be completed each day prior to commencement of site activities:

The following personnel were present at pre-job safety briefing conducted at ____________(time), on___ ___________(date) at_________________________________ (location) and have read the above plan and are familiar with its provisions:

The personnel whose signatures appear below were in attendance at said briefing and are familiar with the provisions of this Health and Safety Plan:

Name	Signature
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

Fully charged ABC Class fire extinguisher available at work site? Yes __
Fully stocked first aid kit available on site? Yes __

All project personnel advised of location of nearest phone? Yes __
All project personnel advised of location of designated medical facility or facilities? Yes __

____

Printed Name of Project Manager or Site Safety Officer

____

Signature and Date

TABLE 1
ACTIVITY HAZARD ANALYSIS
GOLDEN BUTTE MINE SITE

ACTIVITY: Mobilization and Demobilization **ANALYZED BY/DATE:** Mike Ross 6-6-02 **REVIEWED BY/DATE:**

Principal Steps	Potential Hazards	Recommended Controls
Identify the principal steps involved, including the equipment and machinery to be used, and the sequence of work activities	Analyze each principal step for its potential chemical/ toxicological, radiological, biological and physical hazards	Develop specific controls for each potential hazard. Also: • List inspection requirements for the equipment / machinery listed • Specify worker training requirements
1. Overseeing the mobilization of heavy equipment, supplies and trailers to the site 2. Transportation of items to and from the site.	Chemical/Toxicological Hazards: Chemical exposure hazards are listed in Section 8.0 Radiological Hazards: No radiological hazards are anticipated Biological Hazards: 1. Possible biological hazard from spiders, mosquitoes or snakes Physical Hazards: 1. Slip/trip/fall on uneven terrain 2. Thermal stress (hot or cold) 3. Pinch points while handling equipment 4. Lifting heavy objects 5. Movement of heavy equipment which could tip over 6. Connecting of electrical utilities to the trailer	Chemical/Toxicological Hazards: 1. No air monitoring is required for this task 2. Level D PPE as described in Section 9.0 Radiological Hazards: 1. Use Level D PPE to protect against skin contact with poisonous spiders 2. Watch your step, avoid areas with high density of mosquitoes or stagnant water. 3. After and during the field effort, check for ticks in hair and on exposed skin Biological Hazards: 1. Use Level D PPE to protect against skin contact with poisonous spiders 2. Watch your step, avoid areas with high density of mosquitoes or stagnant water. 3. After and during the field effort, check for ticks in hair and on exposed skin Physical Hazards: 1. Watch where you step, be aware that sticks, rocks or other items can be concealed causing you to trip. 2. Refer to Section 13.0 for a discussion on heat/cold stress and severe weather. Wear appropriate clothing and keep hydrated. If weather conditions are dangerous, postpone field work 3. When lifting get assistance when at all possible. Otherwise, size up the load and straddle it with one leg in front of the other, bending at the knees. Get a firm grip and lift with the weight on the legs keeping the back in its natural 'S' curve. Never twist while lifting. Try to lift from waist height to waist height. 3. Wear heavy work gloves when handling equipment. 4. Ensure that the contractor conducts daily inspections of the equipment. 5. Only trained and authorized personnel are to drive transport trucks or heavy equipment. 6. Stay out of the way of people operating heavy equipment.

TABLE 1
ACTIVITY HAZARD ANALYSIS
GOLDEN BUTTE MINE SITE

ACTIVITY: Borrow soil test pit excavation **ANALYZED BY/DATE:** Mike Ross 6-6-02 **REVIEWED BY/DATE:**

Principal Steps	**Potential Hazards**	**Recommended Controls**
Identify the principal steps involved, including the equipment and machinery to be used, and the sequence of work activities	Analyze each principal step for its potential chemical/ toxicological, radiological, biological and physical hazards	Develop specific controls for each potential hazard. Also: • List inspection requirements for the equipment / machinery listed • Specify worker training requirements
1. Excavation of soil and other waste with a backhoe. 2. Backfilling excavation and re-grading the site to existing contours.	Chemical/Toxicological Hazards: Chemical exposure hazards are listed in Section 8.0 Radiological Hazards: No radiological hazards are anticipated Biological Hazards: 1. Possible biological hazard from spiders, mosquitoes or snakes Physical Hazards: 1. Slip/trip/fall on uneven terrain 2. Thermal stress (hot or cold) 3. Pinch points while handling equipment 4. Lifting heavy objects 5. Movement of heavy equipment which could tip over 6. Noise from heavy equipment	Biological Hazards: 1. Use Level D PPE to protect against skin contact with poisonous spiders 2. Watch your step, avoid areas with high density of mosquitoes or stagnant water. 3. After and during the field effort, check for ticks in hair and on exposed skin Physical Hazards: 1. Watch where you step, be aware that sticks, rocks or other items can be concealed by leaves and grass, causing you to trip. Personnel will stay at least 2 feet from the edge of the trench. **Entry into excavations or trenches deeper than 4 feet is prohibited**. 2. Only fully qualified and trained personnel will operate equipment 3. Moving equipment must have properly functioning back-up alarms 4. Spotters on the ground will assist operators in maneuvering vehicles and equipment into tight or confined places 5. Operators will maintain a constant awareness of personnel and equipment in the work area. Workers will wear high visibility vests and stay out of the way of moving equipment and at least two feet from the edge of the excavation. 6. Machinery or equipment shall not run unattended unless secured by the operator. 7. Blade, bucket etc. will be fully lowered or blocked when not in use or being repaired 8. Rollover protection will be used when conditions call for such use 9. Hearing Protection will be worn at 85 decibels on the A scale (dBA) 10. Refer to Section 13.0 for a discussion on heat/cold stress and severe weather. Wear appropriate clothing and keep hydrated. If weather conditions are dangerous, postpone field work. 11. Equipment or machinery will be taken out of service if an unsafe deficiency is noted and will remain out of service until deficiency is corrected 12. Machinery or equipment will not be operated in a manner that will endanger persons or property nor will the safe operating speeds or loads be exceeded 13. Seats will be provided for each occupant of the equipment 14. Safety belts will be used by the operator while equipment is in use 15. Equipment operated on the highway will be equipped with headlights, taillights, brake lights, back-up lights, and turn signals visible from the front and rear 16. All mobile equipment and the areas in which they are operated will be adequately illuminated 17. Mechanized equipment will be shut down prior to and during refueling operations. 18. Whenever equipment is parked, the parking brake will be set and at least two wheels choked. 19. Load capacity ratings will not be exceed at any time 20. No guard, safety appliance, or device will be tampered with 21. Operators will notify their supervisors when taking medication that may impair safe operation of the vehicle 22. Personnel are not permitted to work off of machinery or to use them as ladders 23. Never walk or work directly in back or to the side of heavy equipment without the operator's knowledge and approval 24. When severe weather conditions, such as lighting threatens, all equipment operations will cease and not resume until 30 minutes after last occurrence.

TABLE 1
ACTIVITY HAZARD ANALYSIS FORM
Golden Butte Mine Site

ACTIVITY: Soil Sampling **ANALYZED BY/DATE:** Mike Ross, 6-6-02 **REVIEWED BY/DATE:**

Principal Steps	Potential Hazards	Recommended Controls
Identify the principal steps involved, including the equipment and machinery to be used, and the sequence of work activities	Analyze each principal step for its potential chemical/ toxicological, radiological, biological and physical hazards	Develop specific controls for each potential hazard. Also: • List inspection requirements for the equipment / machinery listed • Specify worker training requirements
• Use a shovel, trowel or hand auger to remove soil from ground • Contain soil in jar or plastic bag • Prepare soil samples at a portable table or on tailgate of truck (note: surface that is used must be covered with a tarp or plastic to prevent spread of contamination).	Chemical/Toxicological Hazards: Chemical exposure hazards are listed in Section 8.0 Radiological Hazards: No radiological hazards are anticipated Biological Hazards: 1. Possible biological hazard from spiders, mosquitoes or snakes Physical Hazards: 1. Slip/trip/fall on uneven terrain 2. Thermal stress (hot or cold) 3. Blisters from hand augers 4. Lifting heavy objects	Chemical/Toxicological Hazards: 1. Air monitoring is not required for this task; see Section 10.0 for dust monitoring. 2. Level D PPE as initial level, see Section 9.0 Radiological Hazards: No radiological hazards are anticipated Biological Hazards: 4. Use Level D PPE to protect against skin contact with poisonous spiders 5. Watch your step, avoid areas with high density of mosquitoes or stagnant water. 6. After and during the field effort, check for ticks in hair and on exposed skin Physical Hazards: 1. Watch where you step, be aware that sticks, rocks or other items can be concealed by leaves and grass, causing you to trip. 2. Refer to Section 13.0 for a discussion on heat/cold stress and severe weather. Wear appropriate clothing and keep hydrated. If weather conditions are dangerous, postpone field work 3. When lifting use the legs to support the weight, instead of the back. Bend at the knees and get a good grasp of the material. If it is awkward or heavy, get help! 4. Wear heavy work gloves when handling hand augers or other objects with sharp edges.

TABLE 1
ACTIVITY HAZARD ANALYSIS FORM
Golden Butte Mine Site

ACTIVITY: Water Sampling **ANALYZED BY/DATE:** Mike Ross, 6-6-02 **REVIEWED BY/DATE:**

Principal Steps	Potential Hazards	Recommended Controls
Identify the principal steps involved, including the equipment and machinery to be used, and the sequence of work activities	Analyze each principal step for its potential chemical/ toxicological, radiological, biological and physical hazards	Develop specific controls for each potential hazard. Also: • List inspection requirements for the equipment / machinery listed • Specify worker training requirements
1. Spring sampling involves walking to the sampling location, kneeling down and collecting water in the sampling device. 2. Well monitoring involves opening the well top, purging a set amount of volume from the well, collecting water quality parameters like temperature, pH and electrical conductivity by putting water in a jar and testing with the appropriate meter, then opening the sample containers and bailing water into the containers. 3. Recording elevation measurements involves opening wells and sending a measuring tape devices down hole and logging the information.	Chemical/Toxicological Hazards: Chemical exposure hazards are listed in Section 8.0 Radiological Hazards: No radiological hazards are anticipated Biological Hazards: 1. Possible biological hazard from spiders, mosquitoes or snakes Physical Hazards: 1. Slip/trip/fall on uneven terrain 2. Thermal stress (hot or cold) 3. Lifting heavy objects 4. Prolonged static posture – standing while well is purging or when pouring water into sampling containers	Chemical/Toxicological Hazards: 1. Air monitoring is not required for this task; see Section 10.0 for dust monitoring. 2. Level D PPE as initial level, see Section 9.0. Use an apron if necessary to avoid splash. PVC or rubber knee height boots may be needed for spring sampling. Radiological Hazards: Radiological hazards are not anticipated Biological Hazards: 1. Use Level D PPE to protect against skin contact with poisonous spiders 2. Watch your step, avoid areas with high density of mosquitoes or stagnant water. 3. After and during the field effort, check for ticks in hair and on exposed skin Physical Hazards: 1. Watch where you step, be aware that sticks, rocks or other items can be concealed by leaves and grass, causing you to trip. 2. Refer to the APP Section 13.0 for a discussion on heat/cold stress and severe weather. Wear appropriate clothing and keep hydrated. If weather conditions are dangerous, postpone field work 3. When lifting use the legs to support the weight, instead of the back. Bend at the knees and get a good grasp of the material. If it is awkward or heavy, get help! 4. Wear heavy work gloves when handling well caps, especially those that may be flush mounted to the ground. 5. Avoid standing or stooping in one place for long periods of time. Take breaks to stretch or pull up a bucket to sit on.

APPENDIX D

SITE SECURITY PLAN

GOLDEN BUTTE MINE SITE INVESTIGATION
USACE CONTRACT NO. DACW05-00-D-0021

October 2002

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D.1 SITE ACCESS AND CONTROL D-1

D.2 SECURITY VIOLATION AND RESPONSE MEASURES D-1

D.0 SITE SECURITY PLAN

MWH shall utilize this site security plan during site investigation and reclamation activities at the Golden Butte Mine near Ely, Nevada. Implementation of the site security plan is crucial to (1) prevent unauthorized entry by persons, and (2) protect disturbance of mine property and field equipment by unauthorized persons. MWH and its subcontractors will be responsible for providing adequate measures against theft of vandalism of equipment left on-site during remediation activities.

D.1 SITE ACCESS AND CONTROL

Currently, site access to Golden Butte Mine is un-restricted via dirt roads. The site is located in a remote area and only receives limited use.

All personnel entering the site during reclamation activities will be required to read and sign the Site-Specific Health and Safety Plan and wear the appropriate personal protective equipment (PPE).

D.2 SECURITY VIOLATION AND RESPONSE MEASURES

If a security violation occurs, the MWH field personnel and Project Manager shall be notified. The field personnel will prepare a written statement describing the events of the security violation with 24 hours of the incident and submit the statement to appropriate law enforcement and MWH Project Manager. The report content will include the nature of the security violation, approximate time period of event, impact of security violation on the facility, and if a delay of work may be expected. The Project Manager will be responsible for taking corrective actions and advising the field personnel of proposed changes in the security measures.

APPENDIX E

STANDARD OPERATING PROCEDURES

GOLDEN BUTTE MINE SITE INVESTIGATION
USACE CONTRACT NO. DACW05-00-D-0021

October 2002

STANDARD OPERATING PROCEDURE

SOP-1
COLLECTION OF SURFACE WATER QUALITY SAMPLES

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1.0 INTRODUCTION

This standard operating procedure (SOP) describes methods and equipment commonly used for collecting environmental samples of surface water for either on-site examination and chemical testing or for laboratory analysis. It also describes procedures for sample handling, labeling and documentation.

The information presented in this SOP is generally applicable to all environmental sampling of surface waters except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions, and equipment different from those described herein.

This document describes multiple methods and a variety of equipment. The appropriate methods and equipment selected will be based on the project specific sampling and analysis plan and site conditions. Specific sampling problems may require the adaptation of existing equipment or design of new equipment. Every field investigation must be conducted in accordance with an approved quality assurance project plan (QAPP). The QAPP identifies the minimum procedures required to assure that goals for precision, accuracy, completeness, representativeness, and comparability of data generated are satisfied. In addition to the QAPP, every field program must have a site-specific field sampling plan (FSP) that defines the proper procedures to be followed in the collection, preservation, identification and documentation of environmental samples and field data.

The same care must be exercised in implementing field investigations and sampling programs that are exercised in planning the program design and analyzing samples in the laboratory. No analytical result is better than the sample from which it was obtained.

Specific organizations and agencies with guidelines and standard procedures that were used include:

- U.S. Environmental Protection Agency (EPA)
- State of Nevada Division of Environmental Protection (NDEP)
- American Society of Testing and Materials (ASTM)
- U.S. Department of the Interior, Geological Survey (USGS)

2.0 DEFINITIONS

Bailer: A long narrow tubular device with an open top and a check valve at the bottom. Bailers may be made of Teflon®, Polyethylene, or stainless steel.

Conductivity: The ability of a solution to conduct electricity.

Dip Sampler: A sample container that may be held directly or attached to a pole, used to collect surface water samples from the surface or just beneath the surface.

Dissolved Oxygen (DO): A measure of the quantity of oxygen dissolved in a water body. DO data is collected in the field using direct measurement probes.

Environmental Sample: A solid or liquid sample collected for chemical or physical analysis. These samples are used to support remedial investigation, feasibility studies, treatability studies, remediation design and performance assessment, and waste characterization.

Peristaltic Pump: A low volume pump that operates by suction lift.

pH: A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity to a maximum value of 14, and decreasing with increasing acidity.

Splitter container: A container that is used for compositing surface water sub-samples, from which are drawn or transferred sample aliquots that are submitted for laboratory analysis.

Temperature: A measure of the thermal energy contained in a given system. Units are commonly in degrees Centigrade (°C) or Fahrenheit (°F).

Turbidity: Cloudiness in water due to suspended and colloidal organic and inorganic material.

3.0 SAMPLING PROCEDURES

3.1 BACKGROUND

Collecting a representative sample from surface water is often difficult because of water movement or stratification. To collect representative samples, sampling bias related to site selection; sampling frequency; sample collection; sampling devices; and sample handling, preservation, and identification must be minimized.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important element not only for assessment and quantification of environmental impact to, or posed by, the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a representative sample has been taken.

3.2 DEFINING THE SAMPLING PROGRAM

Factors that will be considered in developing a sampling program for surface water include study objectives; accessibility; site topography; flow, mixing, and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the investigation(s). For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. The hydrologist developing the sampling plan must therefore understand the mixing characteristics of streams, lakes, ponds, and lagoons.

3.2.1 Sampling Program Objectives

The objective of surface water sampling is to determine the quality of the surface water entering, leaving, or remaining within the site. The scope of the sampling program will therefore consider the sources and potential pathways for transport of contamination to or in a surface water body. Sources may include point sources (leaky evaporation ponds, outfalls, etc.) or non-point sources (e.g., runoff from tailings piles). The major pathways for surface water contamination (not including airborne deposition) are:

- Overland runoff
- Leachate influx to the water body
- Direct waste disposal (solid or liquid) into the water body
- Up-gradient groundwater influx

The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) that encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction; areas of temporary flooding or pooling; artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation); and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, etc., will not be overlooked.

The potential for dispersion of dissolved or sediment-associated contaminants away from the source will also be considered. The dispersion may lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations.

The distribution of particulates within a sample is an important consideration. Many organic compounds are only slightly water-soluble and tend to be adsorbed by particulate matter. Nitrogen, phosphorus, and heavy metals may also be transported by particulates. Surface water samples will be collected with a representative amount of suspended material.

The following factors will be considered in selecting sampling locations:

- site history
- hydrologic boundaries and features of the site
- sources, pathways and potential distribution of contaminants

Based on these considerations the numbers, types, and general locations of required samples up-gradient (for background measurement), on site, and down-gradient can be identified.

3.2.2 Locating Sampling Stations

Accessibility is a key factor affecting sampling costs. The utility of a sample for analysis and characterization of site conditions will be weighed against the costs of collection as controlled by accessibility. Wherever possible, bridges will be used to access sampling stations on streams because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or canoe may also be used to sample locations on lakes and ponds.

Wading is another technique that can be used to obtain a sample. When wading, the sampler must be careful to minimize disturbance of bottom sediments. The stream should be entered downstream of the sampling location. If necessary, the sampling technician will wait for the sediments to settle before taking a sample.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed in order to assure, as closely as possible, that samples are taken where uniform flow and good mixing conditions exist.

Streamflow records can be useful in choosing sampling sites in streams. Streamflow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gauging station is not conveniently located on a selected stream, the project hydrologist will explore the possibility of obtaining streamflow data by direct or indirect methods. Surface water flow rate measurement procedures are presented in SOP-3.

3.2.3 Sampling Frequency

The sampling frequency and the objectives of the sampling program will be defined by the project-specific work plan. For single-event site- or area-characterization sampling, water samples will be collected at the specified sampling locations. If samples are collected primarily for monitoring purposes, such as to define variations and trends at a given location, samples will be collected at a pre-established and consistent intervals as specified in the project-specific work plan (often monthly or quarterly) and during droughts and floods.

The variability in available water-quality data will be evaluated before deciding on the number and collection frequency of samples required to maintain an effective monitoring program. For storm event samples, a record of rainfall intensity over the duration of the storm will be obtained.

3.3 SAMPLE COLLECTION THEORETICAL CONSIDERATIONS

3.3.1 Streams, Rivers, Outfalls, and Drainage Features (Ditches, Culverts)

Methods for sampling streams, rivers, outfalls, and drainage features at a single point vary from simple hand-sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (defined below).

Samples from different depths or cross-sectional locations in the watercourse taken during the same sampling episode will be composited. However, samples collected along the length of the watercourse or collected at different times may reflect differing inputs or dilutions and therefore will not be composited. Generally, the number and type of samples to be taken will depend upon the width and depth of the course, discharge, and the suspended sediment load. The greater the number of individual points that are sampled, the more likely that the composite sample truly will represent the overall characteristics of the water.

In small streams less than about 12-feet wide, a sampling site can generally be located where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite will be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of water quality parameters of pH, temperature, and conductivity will be made, as specified in the Work Plan, on the composite itself. For rivers, it may be necessary to collect several vertical composites.

3.3.2 Lakes, Ponds, and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams do. The relative lack of mixing requires that a high number of samples be obtained.

The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of water quality parameters of pH, temperature, and conductivity should be conducted on each aliquot of the vertical composite. In naturally formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites will be composited to form a single sample. These verticals are often taken along a transect or grid. Normally, a composite consists of several verticals with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately characterize water quality due to the likely existence of poor mixing conditions in these areas. Similarly, additional samples will be taken where discharges, tributaries, land-use characteristics, and other such factors are likely to influence water quality.

3.3.3 Seeps and Springs

Sampling equipment and procedures for seep and spring sampling will be based on site conditions. Samples will generally be collected by compositing subsamples into a splitter container, and then transferring the sample aliquots into the sample bottles. Collection procedures are as follows.

- Use a disposable bailer

- By digging a small hole in the seep and allowing it to fill with water for transfer to the splitter container. A high density polyethylene (HDPE) beaker is used to transfer the subsample aliquot from the depression to the splitter container. This procedure is used particularly in situations where there is insufficient free water for sampling.

Samples may be collected both at the point of discharge and along any overland flow. Specific sample collection locations will be included in the project-specific work plan. The list below provides a summary of sampling equipment and related procedures.

- Trowel and Beaker - dig a small hole in the seep, place the HDPE beaker in the hole, and allow it to fill with water for transfer to sample container

- Disposable bailer - collect water directly from source with a disposable bailer and transfer to splitter container

Transfer from sampling equipment to sample containers should be done in such a manner as to minimize sample aeration and turbulence.

3.4 SAMPLE COLLECTION

The selection of sampling equipment depends on the site conditions and sample type required. The most frequently used samplers are:

- Open tube or bailer
- Dip sampler
- Weighted bottle sampler
- Peristaltic pump
- Hand pump

The dip sampler and the weighted bottle sampler are used most often.

The criteria for selecting a sampler include:

- Ease of disposal and, or decontamination.

- Relative expense (if the item is to be disposed of).

- Ease of operation, particularly if personnel protection required is above Level D.

- Reactivity/contaminating potential - Teflon-coated, glass, stainless steel, or Polyethylene sample chambers are preferred (in that order).

Each sample (grab or each aliquot collected for compositing) will be measured for the project specific water quality parameters (e.g., pH, DO, temperature, specific conductance, and turbidity). Field water quality measurements will be made by placing the meter probe directly into flowing water, whenever possible. If an in-situ measurement is not possible, then the measurements will be made streamside using a decontaminated HDPE beaker, or equivalent.

These parameters will be measured and recorded as soon as the sample is recovered. Other important indicator parameters include biological oxygen demand (BOD), chemical oxygen demand (COD), total organic content (TOC), total solids (TS), alkalinity, hardness, and major ion chemistry. Analysis of these parameters provides information on water mixing/stratification and potential contamination, and will be based on the project-specific data quality objectives. Sample collection procedures are discussed below for three methods: direct collection, discrete-depth, and peristaltic pump.

3.4.1 Direct Collection

With this technique, surface water samples will be collected by filling a decontaminated container, either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Sample containers will be filled directly from the sample collection container, or most commonly, from the splitter container.

Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration that is distributed throughout the water column and in the cross section. Therefore, whenever possible dip samples will be augmented with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

3.4.2 Discrete-depth Collection

A sample can also be collected using a discrete-depth sampling. This instrument is lowered to a desired depth. A weighted-messenger is sent down the tether line and releases a spring mechanism that closes the sampler. This allows collection of a sample at a specific point in the vertical profile. Several of these samples can be combined to provide a vertical composite.

In using this method, a decontaminated sampler, such as a Kemmerer sampler, is lowered gently to the surface of the water and allowed to sink under its own weight to the desired depth. A nylon rope, or equivalent, is used to lower the sampler to the desired depth . Once the sampler reaches the desired depth, it should be moved back and forth gently to displace any water that may have entered the sampler as it was lowered from the surface. The messenger will trip the closure mechanism, trapping the water sample in the sampler. The sampler is then raised slowly to the surface and samples should be transferred to splitter container or directly into the sample bottles.

3.4.3 Peristaltic Pumps

Peristaltic pumps are low-volume pumps that operate by suction lift. These pumps require the use of flexible silicone tubing. The withdrawal rate can be regulated by adjusting the rotor head revolution. While using these pumps, the following procedures will be followed:

- Install clean silicone tubing

- Lower the pump intake to the desired depth and pump water at a rate of 100 ml/min or less

- Discharge water directly into sample containers with minimum turbulence by pouring down the side of the container

3.4.4 Hand Pumps

Hand pumps may operate by peristaltic, bellows, diaphragm, or siphon action. Hand pumps operate much the same way as do peristaltic pumps but utilize hand-cranked versus battery powered pumping.

3.4.5 Sample Filtration

Water samples collected for analysis of dissolved cations and trace metals will be field filtered, whenever possible. Sample filtration will be performed using a peristaltic pump, or hand pump and disposable 0.45 micron cartridge filters. Specific procedures for field filtration are outlined below.

1) A decontaminated HDPE transfer (splitter) container will be used to composite subsamples collected for filtration.

2) Rinse the splitter container a minimum of three times with sample water and then fill.

3) If the sample cannot be immediately filtered, label the transfer container with the site number and time of collection and take to the filtering station.

4) Set up the filtering station either by connecting the peristaltic pump to a battery or, by assembling the handheld vacuum apparatus.

5) Rinse the outside end of the pump tubing that will be placed in the transfer container with sample water from the transfer container. After rinsing, place the tubing in the transfer container.

6) Attach a <u>new</u> disposable cartridge filter to the other end of the pump tubing. It is imperative that a new filter be used for each sample.

7) Turn on the pump and pass a minimum of 250 ml of sample water through the tubing and cartridge filter before collecting the sample.

8) After rinsing the filter, proceed to fill up the proper sample container(s). Filtered water should be passed directly into the sample container from the outlet of the filter.

9) Note on the sample container label and chain of custody form that the dissolved cation/metals sample has been field filtered.

10) Disconnect the filter and tubing from the pump head and dispose.

11) Carefully store the pump in the carrying case to avoid contamination with dirt, etc.

Surface water samples will be filtered as soon as possible, although if field conditions make this impractical, these samples may be filtered within a few hours after collection.

3.4.6 Field Measurements

Dissolved oxygen, pH, specific conductivity, temperature, and turbidity will be measured in the field using hand-held portable meters. The field water quality measurements should be made by directly placing the probe of meter into flowing water whenever possible. If an in-situ measurement is not possible, then the measurements should be made streamside using a decontaminated HDPE beaker.

The field meter will be calibrated, at a minimum, at the beginning of each day's use and checked again at the end of the day. More frequent calibration and, or checks may be necessary if anomalous readings occur. Instructions provided by the equipment manufacturer will be followed to properly calibrate and operate the meter and all calibration results will be recorded in the field book.

Field measurement readings will be recorded in the field notebook and on the field data forms.

3.4.7 Decontamination of Field Equipment

The following water quality sampling equipment will require regular decontamination:

- Field water quality meter(s)
- Glass or plastic beakers used to transfer samples
- Peristaltic pump and tubing

The sample collection equipment will be decontaminated at each monitoring location. The following guidelines will be used to decontaminate sampling equipment:

- Gross contamination on equipment will be scraped off at the sampling site.

- Equipment that will not be damaged by water (water level meter probe and tape, pH/conductivity probe, dissolved oxygen probe, sample transfer containers) will be washed with the Alconox (or a comparable non-phosphate), biodegradable detergent. Equipment will be triple rinsed with potable water followed by a triple distilled or de-ionized water rinse.

- Equipment that may be damaged by water (portable meters) will be carefully wiped clean using a sponge and detergent water, and rinsed with distilled or de-ionized water. Care will be taken to prevent any equipment damage.

- All non-dedicated equipment will be decontaminated between each sample location. When purging groundwater monitoring wells, meter probes will be rinsed with distilled or de-ionized water between each casing volume measurement. After collecting the sample follow the full decontamination procedures.

- Rinse and detergent waters will be replaced with new solutions between sampling events.

Following decontamination, equipment will be placed in a clean area or in clean plastic bags to prevent contact with soils/sediments and airborne material that could contaminate a future sample.

4.0 SAMPLE HANDLING AND FIELD DOCUMENTATION

The purpose of this section is to define the standard protocols for sample handling, documentation and chain-of-custody. The use of proper documentation and chain-of-custody procedures will assure that the adequacy of the sample collection methods and handling can be evaluated.

4.1 SAMPLE HANDLING

4.1.1 Sample Containers

Proper sample preparation practices will be observed to minimize sample contamination and potential repeat analyses due to anomalous analytical results. Prior to sampling, sample bottles will be obtained directly from the analytical laboratory, or laboratory supply-house. The bottles will be labeled (see following section) to indicate the type of sample and sample matrix to be collected. Sample bottles can be either pre-preserved from the laboratory or preservatives can be added in the field during sample collection. In general, 0.5-liter or 1-liter polyethylene or glass bottles will be used for the sample bottles that will be submitted for analysis of general chemical constituents, major inorganic constituents and metals.

Laboratory sample containers will be filled one by one at the monitoring location, secured with the container lid, and any excess water wiped off the exterior. Immediately after collection, the containers will be placed in field coolers with ice. Glass containers will be wrapped with bubble wrap or other appropriate shipping material to prevent breakage.

4.1.2 Sample Preservation

Samples are preserved in order to prevent or minimize chemical changes that could occur during transit and storage. Sample preservation should be performed immediately upon sample collection to assure that laboratory results are not compromised by improper coordination of preservation requirements and holding times. Samples will be preserved immediately and stored on ice in coolers prior to shipping.

For all samples, preservation by cooling to 4°C is required immediately after collection while the samples are held for shipment and during shipment to the laboratory.

4.1.3 Sample Holding Times

Sample holding times are established to minimize chemical changes in a sample prior to analysis and, or extraction. A holding time is defined as the maximum allowable time between sample collection and analysis and, or extraction, based on the nature of the analyte of interest and chemical stability factors.

To meet recommended holding times, analytical samples will be shipped to the analytical laboratory in iced coolers as soon as possible or within 48 hours of collection, if conditions permit**.**

4.1.4 Sample Preparation and Shipping

After collection, samples will be labeled and prepared as described above, and placed on ice in an insulated cooler. The sample containers should be placed in re-sealable plastic storage bags. Samples should be stored in an upright position. A chain of custody form will be placed in a ziploc bag inside the cooler. The coolers will be taped shut and chain-of-custody seals will be attached to the outside of the cooler to assure that the cooler cannot be opened without breaking the seal.

4.2 FIELD DOCUMENTATION

Documentation establishes procedures, identifies written records, enhances and facilitates sample tracking, standardizes data entries, and identifies and establishes authenticity of the sample data collected. Proper documentation also:

- Assures that all essential and required information is consistently acquired and preserved
- Documents timely, correct, and complete analysis
- Satisfies quality assurance requirements
- Establishes chain-of-custody
- Provides evidence for court proceedings
- Provides a basis for further sampling

4.2.1 Sample Labels

Samples collected will be identified by a sample tag attached to the sample bottle. A sample tag or label will be completed and attached to each laboratory sample container just before it is filled. The labels will be filled out with a permanent marker and will include the following information:

- Sample identification
- Sample date
- Sample time
- Sample preservative (if any)
- Sample type (including if raw or field filtered)

Because a variety of preservatives and analytical methods will be employed, care must be taken to avoid mislabeling the containers. If possible, labels should be covered with plastic tape to minimize smudging and ink runs.

4.2.2 Field Documentation

Appropriate field records will be completed in a bound field logbook and, or field data sheets at each site at the time of sample collection. Examples of field data sheets are found in Appendix C of the Water Monitoring Plan. All aspects of sample collection and handling as well as visual observations will be documented in the field logbooks. In general, field logbooks as well as field data records should:

- Record, identify and describe all pertinent sampling and monitoring activities.
- Record quantitative and qualitative information for each sample collected.
- Record and describe all field team activities, including observations and events.

At a minimum, the following information will be recorded in the field at each monitoring station:

- Site location
- Sampler name(s)
- Date and time of sample collection
- Sample identification number(s)
- Type of sample (stream, spring, groundwater, potable water)
- Field water quality measurements (pH, conductivity, temperature, turbidity, DO)
- Sample handling (including filtration and preservation, as appropriate)
- How sample collected (e.g. grab, composite, bailer)
- Number and type of any QA/QC samples collected
- Spring discharge or stream flow, including measurement method (if applicable)
- Weather conditions, including recent precipitation and approximate air temperature
- Field observations, including any unusual conditions or activities in the area

Changes or deletions in the field logbook or on field data forms (see Appendix D) should be lined out with a single strike mark and remain legible. Sufficient information should be recorded to allow the sampling event to be reconstructed without relying on the collector's memory. All field notebooks and data forms will be signed at the end of each day.

4.2.3 Chain-of-Custody

A chain-of-custody (COC) record is used to record the custody and transfer of all samples. The field sampler will be responsible for the care and custody of the water quality samples until they are transferred to a licensed courier. The sampler's responsibility will include:

- Labeling and sealing all sample containers (including custody seals, when appropriate)

- Properly packing the samples with ice for shipment to the laboratory

- Notifying the courier about a sample pick-up and preparing any airbills for shipping samples to the laboratory

- Initiating chain of custody forms

- Notifying the laboratory of all sample shipments

- Assuring that samples are shipped to meet the applicable holding time(s)

A chain-of-custody form will accompany each sample cooler and include the following information.

- Project name or number
- Sampler's name and signature
- Sample identification number(s)
- Date and time of sample collection
- Sample matrix
- Number of sample containers
- Analyses requested

- Filtration completed or required
- Method of shipment (with airbill number if applicable)
- Any additional instructions for the laboratory

Upon receipt, laboratory personnel will inspect the samples and record their condition and temperature on the chain-of-custody form. The laboratory will immediately report the presence of broken custody seals to MWH's project laboratory liaison. The laboratory liaison, after consulting with the Project Manager and the laboratory's project manager, will decide whether or not to analyze the samples. Decision criteria that will be used to help in determining if the samples should be analyzed include:

- If the cooler custody seal is broken is there any sort of documentation that may indicate who broke the seal, e.g., a customs declaration, or a notation from the shipping company;

  ➢ The samples can be analyzed

- If the cooler appears intact, and the samples inside are ok, e.g., the individual bottle custody seals are intact;

  ➢ The samples can be analyzed

- If the cooler custody seal, and the individual bottle seal(s) have been compromised;

  ➢ Then the samples <u>should not</u> be analyzed

The COC forms will be completed by the laboratory and forwarded with the final laboratory results.

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STANDARD OPERATING PROCEDURE

SOP-2
GROUNDWATER SAMPLE COLLECTION

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1.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes methods and equipment commonly used for collecting environmental samples of groundwater for either on-site examination and chemical testing, or for laboratory analysis. It also describes procedures for sample handling, labeling and documentation. The information presented in this SOP is generally applicable to all environmental sampling of groundwaters except where the analyte(s) may interact with the sampling equipment.

This document describes multiple methods and a variety of equipment. Appropriate methods and equipment will be selected based on the sampling and analysis plan and site conditions. Specific sampling problems may require the adaptation of existing equipment or design of new equipment.

This technical procedure establishes a uniform methodology to ensure that high quality samples, representative of the groundwater resource of interest, are consistently obtained. The scope is intended to provide guidance while preparing for, and conducting, field sampling activities. The SOP should be used with a project specific field monitoring plan and quality assurance project plan.

The groundwater collection procedures presented in the following sections were developed using standard industry-accepted practices, as well as international organization and agency guidelines and standard practices. The same care must be exercised in implementing field investigations and sampling events that are exercised in planning the program design and analyzing samples in the laboratory. No analytical result is better than the sample from which it was obtained.

Specific organizations and agencies with guidelines and standard procedures that were used include:

- U.S. Environmental Protection Agency (EPA)
- State of Nevada (U.S.) Division of Environmental Protection (NDEP)
- American Society of Testing and Materials (ASTM)

2.0 DEFINITIONS

2.1 DEDICATED PUMP SYSTEM

A dedicated pump system is a permanently installed device for removing water from a well. The system is not removed from the well and does not have the potential to become contaminated between uses.

2.2 NON-DEDICATED SAMPLING APPARATUS

A non-dedicated sampling apparatus is sampling equipment that may contact groundwater samples from more than one well. This term is also used to describe equipment that is only used for sampling a single well, but is removed from the well and could potentially become contaminated.

Examples of non-dedicated equipment include a pump used to sample multiple wells, bailers and field meters.

2.3 BAILER

A bailer is a tubular device, with a check-valve at the top and/or bottom used for collecting and removing groundwater from wells. The three most common types of bailers are as follows:

- Single check value: A single check valve sampler collects the sample from the top of the water column. The typical sample transfer occurs by inserting a tube into the bottom of the bailer, pushing up the check valve which allows the water to be released into the sample container. If used for VOC sampling the bailer should have a sample cock or draft valve at or near the bottom of the sampler allowing withdrawal of the sample from the well below the exposed surface water. Otherwise, discard the first few centimeters of sample at the bottom of the sampler.

- Douple check value: The double check valve sampler allows for point source sampling at a specific depth. The liquid will pass through the sampler while it is descending until the desired depth is reached. Once retrieval of the sample commences, both check valves close simultaneously, thereby allowing the specific depth to be sampled.

- Thief or messanger sampler: This type of sampler also allows for point source sampling at a specific depth. A weighted messenger is dropped down the suspension line and closes the sampling vessel thus obtaining a sample at the desired depth.

To avoid potential sources for contamination keep the bailer suspension lines off the ground and away from any other potentially contaminating sources to minimize the possibility of being carried down into the well. If needed, a decontaminated tarp or plastic bag is recommended for storage of the bailer suspension line.

2.4 POSITIVE PRESSURE PUMP

A positive pressure pump is a device for removing water from well by forcing water to the surface through positive pressure when operated below the water level in a well. A positive pressure pump may be operated electrically, mechanically, or by air/nitrogen pressure. Submersible impeller, bladder, and check valve pumps are common types of positive pressure pumps.

2.5 SUCTION LIFT PUMP

A suction lift pump is a device for removing water from well by negative pressure (suction). Direct line, peristaltic and centrifugal pumps are the three types of suction lift pumps. The limitation for lifting water by suction is usually six to eight meters. These pumps are only acceptable for non-volatile analytes and analytes that are not affected by aeration or changes in pH. They are useful as purging devices for shallow groundwater wells.

MWH prefers to use the peristaltic pump when a suction lift pump is required. This is the only suction lift pump, of the three mentioned above in which the liquid being sampled moves entirely within the sample tubing. The groundwater sample never contacts the actual pump apparatus during sampling thus eliminating a possible source of sample contamination from the actual pump, lubricants or parts.

Standard silicon tubing is the most commonly used sample tubing. Most pump manufacturers and rental companies offer acceptable tubing lined with TFE-fluorocarbons or Viton. Medical grade silicon tubing is recommended for organic sampling by the National Council of the Paper Industry for Air and Stream Improvement; however, it is limited to use over a restricted range of ambient temperatures. Standard silicon tubing uses an organic vulcanizing agent, which has been shown to leach into samples.

2.6 WELL STORAGE VOLUME

Well storage volume is defined as the volume of water enclosed by the well casing and screen gravel/sand pack at equilibrium.

2.7 GROUNDWATER SAMPLE

A groundwater sample is defined as water acquired from a well for chemical analyses that is representative of groundwater within the aquifer or the portion of the aquifer being sampled.

2.8 SAMPLE BOTTLES

Sample bottles are containers specifically designed and prepared for storing liquid samples. Sample bottle type, material, size, and type of lid are specific for particular groups of analytes. Sample bottles must be properly cleaned and prepared by a laboratory or the bottle manufacturer. Coordinate with selected analytical laboratory for bottle type and preparation requirements.

2.9 ACCEPTABLE MATERIAL

Acceptable materials are defined as pump systems that have minimal effect on water quality when used to obtain groundwater samples from wells. The use of permissible pumps is dependent on the analyses being conducted on the acquired samples. The parts of permissible pumps that will contact the groundwater sample contain only acceptable materials.

3.0 REQUIRED GENERAL PROCEDURES

The following is a listing of general procedures that should be followed during every sampling event.

- Groundwater samples will be collected in quantities and types as directed by the Project Manager and project work documents.
- Water level data collection (see SOP-4 Groundwater Level Measurement).
- Determination of well storage volume (see Section 6.2.2).
- Prior to collection of groundwater samples, the well (or piezometer) should be purged.
- All instruments used for field analyses should be calibrated in accordance with the instructions provided.
- All non-dedicated sampling equipment will be decontaminated before and/or after each use.
- Samples will be collected in properly prepared containers of the appropriate size and type. All samples will be appropriately labeled and sealed.
- Samples will be stored and transported in coolers at 4-degrees Celsius. Chain-of-custody will be maintained in accordance with chain-of-custody procedures
- Daily field activities and sampling events will be documented in the field logbook and field data sheets.
- All variations from established procedure will be documented on the field data sheets, the field logbook and will be approved by the Project Leader.

4.0 EQUIPMENT AND MATERIALS

If wells are equipped with permissible and dedicated pump systems, equipment to operate the dedicated pump systems (i.e., air compressor, compressed air or nitrogen cylinders, electric generator, etc.) as well as and non-dedicated sampling apparatus, such as surface discharge tubing and valving or bailer(s) for sampling free floating product, may be necessary.

If wells do not have permissible and dedicated pump systems, permissible pump systems or bailers and accessories of small enough diameter to enter the wells will be necessary. All equipment that could contact the sample will be made of acceptable materials.

Sample bottles and preservatives appropriate for the parameters to be samples will be necessary. Coordinate with selected analytical laboratory for bottle type and preparation requirements.

Field test equipment:

- pH meter and standards
- Conductivity meter and standards
- Dissolved oxygen meter
- Turbidity meter and standards
- Thermometer
- Filtration apparatus (0.45 micron)
- Water-level measuring device
- Coolers and ice packs
- Distilled or deionized water
- Decontamination equipment (scrub brushes, gloves etc.) and solutions (non-phosphate detergent)
- Permanent, waterproof ink pens and markers
- Sample labels and seals
- Well specifications
- Field data sheets and logbook
- Chain-of-custody forms (provided by selected laboratory)
- Plastic sheeting (disposable)

5.0 SAMPLE COLLECTION PROCEDURE

5.1 DECONTAMINATION

All non-dedicated sampling equipment that may contact the sample must be decontaminated at the beginning of each sampling day and after each use. Non-dedicated pumps or bailers require decontamination of internal and external parts prior to being lowered into the well. Non-dedicated equipment will first be washed with clean tap water (whose chemistry is known and acceptable), then washed with a non-phosphate detergent, followed by a triple rinse of distilled water.

5.2 SAMPLE QUANTITIES, TYPES, AND DOCUMENTATION

Samples will be collected in quantities and types as specified in the filed sampling plan and project objectives.

Daily field activities and sampling events will be documented in the field logbook and field data sheets. Samples will be transferred to the analytical laboratory(s) under formal chain-of-custody procedures.

5.3 SAMPLE CONTAINERS

All sample bottles must be properly cleaned and prepared. Coordinate with selected analytical laboratory for appropriate sample bottle types and preparation requirements. All groundwater samples will be labeled and sealed and immediately placed in 4 degrees Celsius coolers with securely closed lids and custody seals on the outside of the cooler for storage and transport. Samples must be received by the analytical laboratory in sufficient time to conduct the requested analyses within the specified holding time. A temperature blank will be placed inside each cooler to verify the internal temperature of the cooler upon arrival at the laboratory.

5.4 ACCEPTABLE MATERIALS

Stainless steel and fluorocarbon resin (Teflon, PTFE, FEP, or PFA) are acceptable materials that may contact groundwater samples. Glass is an acceptable material for contacting samples except when silica or fluoride analysis are to be performed. Plastics (PVC, polyethylene**,** polypropylene, tygon) are an acceptable material for contacting samples when the analyses are for inorganic analytes (general water quality indicators, major anions and cations, trace metals and radionuclides).

5.5 GROUNDWATER SAMPLE COLLECTION

This section provides guidance for collecting a representative groundwater sample, which can be used for water quality characterization. There are three steps included in the sample collection process:

1) Groundwater-level measurement
2) Well purging
3) Sample collection

5.5.1 Groundwater-level Measurement

Groundwater-levels will be measured before well purging to allow calculation of a casing volume. The water level will be measured after purging to verify that it has recovered to at least 80% of the static water level prior to sampling.

Water-level measurements will be made directly using an electronic water-level sounder. The sounder consists of a graduated tape, accurate to 0.01-feet, with a probe at the end of the tape. The probe is lowered into the well until water or moisture is encountered activating audible and visual signals on the instrument reel at the surface. The water level is then read directly from the graduated tape.

5.5.2 Well Purging

Water that remains in a well between sampling events may not be representative of groundwater in the water-bearing unit. Purging is required to remove this stagnant water and allow formation water to enter the well screen and casing. Purge water from a well using the same type of device (pump or disposable bailer) that will be used for sampling.

Groundwater samples will be removed from the well with the use of a permissible pump or bailer. Electric-powered positive-pressure pumps, as defined in Section 2.5, made of acceptable materials are permissible to use for acquiring any groundwater sample. Air/nitrogen pressure activated positive-pressure pumps made of acceptable materials are permissible to use for acquiring any groundwater sample if the air/nitrogen does not contact the sample. Positive-pressure pumps that mechanically force water through check valves are also permissible for acquiring groundwater samples. Bailers made of acceptable materials are permissible for acquiring groundwater samples.

Peristaltic pumps and airlift pumps are not the preferred equipment for acquiring groundwater samples but are permissible when samples are to be analyzed for analytes that are not volatile, are not affected by aeration, and are not affected by changes in pH. Other types of pumps (air-lift, centrifugal, peristaltic, recirculation, etc.) may be used for purging groundwater from wells prior to sample acquisition, if:

(1) pump materials contacting groundwater are acceptable;

(2) pumping does not aerate or change the pH of the groundwater; and,

(3) pumped water does not mix with remaining formation water during pumping or after the pumping is stopped.

Prior to any evacuation or sampling, all pumps and other sampling devices that are not disposable will be decontaminated.

A minimum of three well casing volumes will be recovered during the purging operation, if possible. However, it may be impractical to purge three casing volumes. If this is the case, then:

- If the well contains a small volume of water purge the well dry, and after allowing for a minimum recovery of twelve hours, collect the sample.

- If the well contains to great of a volume to be evacuated using a small disposable bailer, check field water quality parameters a minimum of five times. If the parameters appear to stabilize; e.g., no more than a ten-percent difference among the last three values; collect a sample. If this process does not work, then another type of evacuation device is needed.

Depth to water (DTW) and total well depth (TD) will be measured prior to purging the well to calculate the volume of water that needs to be evacuated. A casing volume (CV) is calculated using the following equations:

$$WC = (TD - CS) - (DTW-CS)$$

and,

$$\text{gallons/foot} = (D)^2/24.5$$

and,

$$CV = \text{gallons/foot} \times WC$$

where,

WC = height of the water column in feet
TD = total well depth in feet (from top of casing)
CS = casing stick-up in feet
DTW = depth to water level surface (from top of casing) (feet)
gallons/foot = number of gallons of water per one foot of casing
D = inside diameter of the casing in inches
CV = one casing volume in gallons

Field water quality parameters will be measured and recorded for each well volume purged:

- pH
- specific conductivity
- dissolved oxygen
- temperature

If these parameters have not stabilized (± ten percent) after purging three well volumes, additional purging may be performed. The meters and probes will be rinsed with distilled or de-ionized water between each casing volume.

If a monitoring well or piezometer is artesian, or exhibits artesian characteristics during any particular sampling event, then well purging is not required for that event.

All purging activities will be thoroughly documented on the groundwater data sheet and in the field logbook to assure that the adequacy of the procedures can be evaluated.

5.5.3 Collecting the Groundwater Sample

5.5.3.1 Groundwater Sample Collection for Laboratory Analyses

Groundwater aliquots will be composited in a splitter container, and the raw water samples will be transferred directly from the splitter container to the laboratory sample container. For those samples that require filtration, the groundwater sample will be transferred through the filtration apparatus to the laboratory sample container.

Major Cations, Trace Metals and Total Dissolved Solids

Samples for major cations, trace metals and total dissolved solids (TDS) will be immediately filtered after acquisition. Filtration is best accomplished with the use of an in-line filter system in which the sample is directly fed from the pump discharge port, bailer, or splitter container, through the filter and into the appropriate sample bottle. The filter pore size will be 0.45 micron. New filters and filter tubing will be used for each sample. The groundwater samples for metals analyses will be preserved with nitric acid ($HN0_3$) to a pH less than 2. The TDS samples will not be acidified. The sample bottles will be 0.5-liter or 1-liter high-density polyethylene (HDPE) containers.

The project objectives or field sampling plan also may specify the collection of raw, or unfiltered metal sample aliquots. These aliquots will be collected directly from a pump discharge port, bailer, or splitter container into appropriate sample bottles and preserved with nitric acid ($HN0_3$) to a pH less than 2. The only exception is analysis of chromium VI, in which case preservatives will not be added to the sample.

Cyanide

Samples for cyanide analyses will be collected directly into appropriate sample bottles from the splitter container, bailer or the pump port. Samples will not be filtered nor should they be allowed to overflow the sample bottle. Samples will be immediately preserved with sodium hydroxide (NaOH) to a pH greater than 12. The appropriate bottle will be 0.5-liter or 1-liter HDPE container.

Major Anion, Biological Oxygen Demand, pH and Total Suspended Solids

Samples for major anions (chloride, fluoride, sulfate, alkalinity, acidity), biological oxygen demand (BOD), pH, and total suspended solids (TSS) will be collected directly into appropriate sample bottles from the bailer, pump discharge port or splitter container. These samples will be un-filtered and un-preserved. The sample bottles for major anions, pH and TSS will be 0.5-liter or 1-liter HDPE containers. BOD samples will be transferred to 0.25-liter or 0.5-liter glass bottles.

The sample bottle for BOD will be filled to the very top to eliminate any headspace. There should be no air bubbles in the bottle once the cap has been fastened; if air is present, a new sample will be taken by the same procedure.

Nitrogen Species, Total Phosphate, Chemical Oxygen Demand, and Oil and Grease

Groundwater samples for nitrogen species (nitrate [NO_3], nitrite [NO_2], total kjeldahl), total phosphate, chemical oxygen demand (COD), and oil and grease analyses will be raw, unfiltered aliquots. The sample bottles will be filled directly from the splitter container, bailer or pump discharge port. The appropriate bottle for nitrogen species and total phosphate sample analyses is a 0.5-liter or 1-liter HDPE container. Oil and grease samples will be collected in 1-liter amber glass bottles. The COD samples will be collected in 0.5-liter glass bottles. Samples will be preserved with sulfuric acid (H_2SO_4) to pH less than 2.

Oil and grease samples will be collected in 1-liter amber glass bottles. The COD samples will be collected in 0.5-liter glass bottles. Samples will be preserved with sodium thiosulfate ($Na_2S_2O_3$).

Extractable Base-Neutral/Acid Organics, Phenolic Compounds, PCB and Pesticides

Samples for extractable base-neutral/acid organic, phenolic compound, PCB and/or pesticide analyses will be collected directly from a pump discharge port, bailer or splitter container in appropriate sample bottles with teflon lined lid and appropriate preservative. Samples should not be allowed to overflow the sample bottle and will not be filtered.

Purgeable Volatile Organics

Samples for purgeable volatile organics will be obtained after other bottles (for other analytes) have been acquired for each well. Samples for purgeable volatile organics will be extracted from the well using a pump or bailer and will be collected directly from the pump discharge tube, bailer or splitter container into properly cleaned and prepared 40 ml or 125 ml glass vial. The vial will be allowed to overflow approximately 2 to 3 vial volumes. Contact with air and sample agitation should be minimized. If necessary, pumping rates will be significantly reduced during sampling for volatile organics. These samples will not be filtered or preserved. Immediately after collection, a teflon lined silicon septum cap will be tightened onto the vial. There should be no air bubbles remaining within the vial once the cap has been fastened; if air is present, a new sample will be taken by the same procedure. Samples for purgeable aromatic hydrocarbons (EPA Methods 6020 or 8020) may be preserved with hydrochloric acid (HCl) to increase holding time.

5.5.3.2 Field Parameter Measurements

Unfiltered aliquots of the groundwater also will be collected for field water quality parameter (pH, specific conductivity, turbidity, temperature, and dissolved oxygen) measurement, recording the in-field measurements on the field data sheet and in the field book.

Calibration of Instruments

All instruments used for field analyses will be calibrated daily prior to use, at a minimum. Calibration will be in accordance with the manufacturer's specifications (provided with the instrument).

pH

A pH meter will be used to measure the pH of the sample on sample of purged water that was obtained just before or after sampling. Measurements will be made immediately on the obtained sample. Calibration will be in accordance with the manufacturer's procedures (provided with the instrument). Calibration will be performed with standardized buffered pH solutions bracketing the range of expected pH and conducted at the beginning of each day. After each reading, the probe will be thoroughly rinsed with distilled or deionized water. The pH will be recorded to one-tenth (or one-hundredth if meter is stable enough) of a pH unit.

Conductivity Measurement

A conductivity probe will be used for conductivity measurement on an aliquot of purged water obtained just before or after sampling. Measurements will be made as soon as possible on the obtained aliquot. The meter will be calibrated in accordance with manufacturer's procedures (provided with the instrument) with standardized KCl solutions. At a minimum, calibration will be performed at the beginning of each day's use. The conductivity will be recorded to two significant figures. The temperature of the sample at the time of conductivity measurement will also be recorded. The probe must be thoroughly rinsed with distilled/deionized water before and after each use.

Water Temperature

A thermostat contained in the pH or conductivity meter will be used to measure the temperature of the water on an aliquot of purged water obtained just before or after sampling. The thermometer reading will be allowed to stabilize and will be recorded to the nearest 0.1 degree centigrade.

Dissolved Oxygen Measurement

A dissolved oxygen meter is used to measure dissolved oxygen (DO) in groundwater samples. Measurements will be made immediately on aliquots obtained just before or after sample acquisition. The probe must be thoroughly rinsed with distilled or deionized before and after each use. Measurements will be recorded to the nearest 0.1 mg/l (parts per million [ppm]) concentration.

Turbidity Measurements

A portable turbidity meter will be used to make turbidity measurements on aliquots of water samples obtained just before or after sample acquisition. Measurements will be made as soon as possible on the obtained aliquot. The outside of the glass vials used for containing the aliquot for measurement must be wiped thoroughly dry before and after each use. Measurements will be recorded to the nearest 0.1 NTU when less than 1 NTU; the nearest 1 NTU when between 1 and 10 NTU; and the nearest 10 NTU when between 10 and 100 NTU.

5.6 CAPTURE AND DISPOSAL OF PURGE WATER AND DECONTAMINATION SOLUTIONS

5.6.1 Purge Water

If stipulated by the project objectives and field monitoring plan, purged groundwater will be captured and contained in 55-gallon drums or suitable tank(s). If required, each drum or tank containing captured purge water will be properly labeled with a label as to the contents, the well(s) from which the contained purge water originated and the date in which the contents were generated. Storage of the drums or tanks will be as specified in the project work documents or as directed by the Project Manager.

Captured and contained purge water will be characterized for discharge, treatment and/or disposal. Characterization of the captured and contained purge water should be specified in the project work documents or by the Project Manager, but could rely on the analytical results of groundwater samples associated with each drum or tank, or could involve direct sampling and analyses of the contained water.

The requirements and options available for discharge, treatment and/or disposal are dependent upon many variables such as chemical consistency, local regulations, and location of site. Discharge, treatment and, or disposal of captured and contained purge water must be in accordance with local, state and federal regulations and will be specified in the project work documents.

5.6.2 Decontamination Solutions

Decontamination waste solutions that are generated during groundwater sampling include: spent detergent wash solutions; spent tap water rinses; any spent weak acid rinses, any spent methanol rinses; and spent final distilled or de-ionized water rinses. Spent acid and methanol rinses will be captured and contained in plastic buckets or drums. Other spent decontamination waste solutions will be captured and contained in appropriately sized buckets or drums if a reasonable potential exists for the spent solutions to contain hazardous substances. Project work documents will address, or the Project Manager will determine, whether spent decontamination solution requires capture and containment.

Captured and contained decontamination solutions will be subject to the same procedures as described for purge water. Some differences are as follows:

(1) acid solutions will be neutralized with lime prior to discharge or disposal;

(2) methanol solutions may be able to be evaporated if segregated from other decontamination solutions, if generated in small enough quantities, and if conditions are favorable; and,

(3) if quantities are sufficiently small, decontamination solutions (detergent washes, rinse waters, neutralized acid solutions) may be added to the captured and contained purge water that corresponds to the same well sampling effort.

6.0 SAMPLE HANDLING AND DOCUMENTATION

Documentation for sampling groundwater includes labeling sample bottles, completing field data sheets and chain-of-custody records and securing individual samples or sample coolers with chain-of-custody seals.

6.1 SAMPLE HANDLING

6.1.1 Sample Containers

Proper sample preparation practices will be observed to minimize sample contamination and potential repeat analyses due to anomalous analytical results. Prior to sampling, sample bottles will be obtained directly from the analytical laboratory, or laboratory supply-house. The bottles will be labeled (see following section) to indicate the type of sample and sample matrix to be collected. Sample bottles can be either pre-preserved from the laboratory or preservatives can be added in the field during sample collection. In general, 0.5-liter or 1-liter polyethylene or glass bottles will be used for the sample bottles that will be submitted for analysis of general chemical constituents, major inorganic constituents and metals.

Laboratory sample containers will be filled one by one at the monitoring location, secured with the container lid, and any excess water wiped off the exterior. Immediately after collection, the containers will be placed in field coolers with ice. Glass containers will be wrapped with bubble wrap or other appropriate shipping material to prevent breakage.

6.1.2 Sample Preservation

Samples are preserved in order to prevent or minimize chemical changes that could occur during transit and storage. Sample preservation should be performed immediately upon sample collection to assure that laboratory results are not compromised by improper coordination of preservation requirements and holding times. Samples will be preserved immediately and stored on ice in coolers prior to shipping.

For all samples, preservation by cooling to 4°C is required immediately after collection while the samples are held for shipment and during shipment to the laboratory.

6.1.3 Sample Holding Times

Sample holding times are established to minimize chemical changes in a sample prior to analysis and, or extraction. A holding time is defined as the maximum allowable time between sample collection and analysis and, or extraction, based on the nature of the analyte of interest and chemical stability factors.

To meet recommended holding times, <u>most</u> **samples will be shipped to the analytical laboratory in iced coolers as soon as possible or within 48 hours of collection**, if conditions permit**.**

6.1.4 Sample Preparation and Shipping

After collection, samples will be labeled and prepared as described above, and placed on ice in an insulated cooler. The sample containers should be placed in re-sealable plastic storage bags. Samples should be stored in an upright position. Coolers sent to the analytical laboratories should be chilled with ice. The coolers will be taped shut and chain-of-custody seals will be attached to the outside of the cooler to assure that the cooler cannot be opened without breaking the seal.

6.2 FIELD DOCUMENTATION

Documentation establishes procedures, identifies written records, enhances and facilitates sample tracking, standardizes data entries, and identifies and establishes authenticity of the sample data collected. Proper documentation also:

- Assures that all essential and required information is consistently acquired and preserved
- Documents timely, correct, and complete analysis
- Satisfies quality assurance requirements
- Establishes chain-of-custody
- Provides evidence for court proceedings
- Provides a basis for further sampling

6.2.1 Field Documentation

Appropriate field records will be completed in a bound field logbook and, or field data sheets at each site at the time of sample collection. All aspects of sample collection and handling as well as visual observations will be documented in the field logbooks. In general, field logbooks as well as field data records should:

- Record, identify and describe all pertinent sampling and monitoring activities.
- Record quantitative and qualitative information for each sample collected.
- Record and describe all field team activities, including observations and events.

At a minimum, the following information will be recorded in the field at each monitoring station:

- Site location
- Sampler name(s)
- Date and time of sample collection
- Sample identification number(s)
- Type of sample (stream, spring, groundwater, potable water)
- Field water quality measurements (pH, conductivity, temperature, turbidity, DO)
- Sample handling (including filtration and preservation, as appropriate)
- How sample collected (e.g. grab, composite, bailer)
- Number and type of any QA/QC samples collected
- Spring discharge or stream flow, including measurement method (if applicable)
- Depth to groundwater (if applicable)
- Well purge volumes and time (if applicable)
- Casing stick-up (if applicable)
- Weather conditions, including recent precipitation and approximate air temperature
- Field observations, including any unusual conditions or activities in the area

Changes or deletions in the field logbook or on field data forms (see Appendix C) should be lined out with a single strike mark and remain legible. Sufficient information should be recorded to allow the sampling event to be reconstructed without relying on the collector's memory. All field notebooks and data forms will be signed at the end of each day.

6.2.2 Chain-of-Custody

A chain-of-custody (COC) record is used to record the custody and transfer of all samples. The field sampler will be responsible for the care and custody of the water quality samples until they are transferred to a courier, and ultimately, the analytical laboratory. The sampler's responsibility will include:

- Labeling and sealing all sample containers (including custody seals, when appropriate)
- Properly packing the samples with ice for shipment to the analytical laboratory
- Notifying the courier about a sample pick-up and preparing any airbills for shipping samples to the laboratory
- Initiating chain-of-custody forms
- Notifying the laboratory of all sample shipments
- Assuring that samples are shipped to meet the applicable holding time(s)

A chain-of-custody form will accompany each sample cooler and include the following information:

- Project name and address
- Project number
- Sampler's name and signature
- Sample identification number(s)
- Date and time of sample collection
- Sample matrix
- Number of sample containers
- Analyses requested
- Filtration completed or required
- Method of shipment (with airbill number if applicable)
- Any additional instruction for the laboratory

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STANDARD OPERATING PROCEDURE

SOP-3
SURFACE WATER FLOW MEASUREMENT

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1.0 PURPOSE AND SCOPE

This technical procedure describes general methodologies for collecting surface water flow measurements from streams, rivers, springs, irrigation canals and open culverts. For any variation from this standard operating procedure (SOP), the work plan will take precedence.

This SOP is designed to cover general techniques for obtaining valid, representative flow measurements from surface waters in open conduits. The scope is intended to provide guidance while preparing for, and during, actual field sampling activities for a particular project.

This SOP describes methods for measuring surface water discharge in streams, seeps, adits, and pipes. Discharge is defined as the volume rate of flow of water, expressed in cubic feet per second (cfs), including any substances suspended or dissolved in the water. Methods for measuring discharge are based on a variety of flow conditions. Many discharge measurement methods are required because flow conditions differ from site to site. This SOP describes probable flow conditions that may be encountered and methods used to obtain discharge measurements. A complete discussion of all available flow measurement techniques and the theory behind them is beyond the scope of this text.

Because of the dynamic nature of surface water behavior, flow measurement by the methods described in this document may, on occasion, be impossible at some sites. It is understood that if unmeasurable flow conditions are encountered at any of the surface water data collection sites which are to be measured in this program, the field team will attempt to measure flow at a point upstream or downstream of the site and will note this point relative to the marked data collection point. Whether or not a measurement is made, the team will note the conditions that inhibited accurate flow measurement.

Selection of the streamflow measurement methods in this SOP were based on the following conditions:

- Permanent control structures (such as flumes or weirs) may exist at some of the sites

- In the absence of a permanent control structure such as a flume, a current meter, or a portable flume or weir may be used to measure discharge

- Staff gages may be installed at sampling station locations identified in the surface water monitoring program; and

- A few locations may be appropriate for volumetric measurement of discharge

The method of discharge measurement to be used at each site will be described in the field notebook for the site. Each of these methods will be presented in the following format:

- Method name
- Required measurement conditions
- Equipment
- Maintenance and calibration procedures
- Field procedures
- Discharge calculations

2.0 PROCEDURES

2.1 CONTROL STRUCTURES

Permanent control structures such as weirs and flumes can be used to determine discharge. These structures have regular dimensions that allow for a constant relationship between water level and discharge. This section describes the use of Parshall and cutthroat flumes to measure discharge. This section also provides general guidelines for the use of weirs in measuring discharges.

2.1.1 Theoretical Considerations

A calibrated constriction placed in a stream channel changes the level of the water in or near the constriction. By knowing the dimensions of the constriction, the discharge though the constriction will be a function of the water level. A simple depth determination near the constriction provides a discharge measurement. Flumes are constructed so that a restriction in the channel causes the water to accelerate, producing a corresponding change (drop) in the water level. The head can then be related to discharge.

Flumes are specially shaped, open-channel, flow sections with a restriction in channel area and, in many examples, with a change in channel slope. Either or both of these shape changes cause velocities to increase and water levels to change while passing through the flume. Typical flumes consist of three sections:

- A converging section to accelerate the approaching flow
- A throat section, whose width is used to designate flume size
- A diverging section, designed to ensure that the level downstream is lower than the level in the converging section

The stage of a stream is the height of the water surface above an established datum plane. The water-surface elevation referred to some arbitrary gage datum is called the "gage height." Stage or gage height is usually expressed in feet or inches.

2.1.2 Required Measurement Conditions

Ideally, flowrate through a flume may be determined by measurements at a single point some distance downstream from the inlet and above the throat. The single measurement indicates the discharge rate only if critical or supercritical flow is achieved in the flume. By definition, critical flow is that for which the ratio of inertiaforce to the force due to gravity (Froude number) is unity. Supercritical flow occurs when the Froude number, F, exceeds unity; this flow has a high velocity and is usually describedd as rapid, shooting and torrential. If the Froude number is less than one, subcritical flow occurs, commonly due to a condition referred to as submergence; this flow has a low velocity and is often described as tranquil and streaming. Additional information concerning the use of flumes under all flow conditions, including submergence, is presented in Rantz and others (1982).

2.1.3 Equipment

For purposes of discharge measurements, existing flumes located at surface water data collection sites will be inspected and measured prior to use in the surface water program. Additional flumes may be installed at some sites as warranted.

Parshall Flume: The Parshall flume consists of a converging section with a level floor, a throat section with a downward sloping floor, and a diverging section with an upward sloping floor. The principal feature of the Parshall flume (developed by R. Parshall in 1922) is an approach reach having converging sidewalls and a level floor, the downstream end of which is a critical-depth cross-section. Critical flow is established in the vicinity of that cross-section by having a sharp downward break in the bed slope of the flume. The bed slope downstream from the level approach section is therefore supercritical. The primary stage measurement is made in the approach reach at some standard distance upstream from the critical-depth cross-section. The Parshall flumes are equipped with standard USGS vertical staff gages. The staff gages will be used to measure gage height to the nearest 0.02 of a foot. The stage/discharge relationship is provided by the manufacturer.

Cutthroat Flume: The cutthroat flume lacks a parallel-wall throat section. It is a flat-bottomed device whose main advantage is extreme simplicity of form and construction. The level flume floor permits placing the device directly on an existing channel bed, without further excavation. The rectangular cutthroat flume is dimensionally defined by a characteristic length, L, and by the throat width, W. All other flume dimensions are derived from these two dimensions. For free flow conditions, on the head H_a at the upstream gage location is needed to determine discharge. For submerged conditions, both the upstream head and the downstream head (H_b) are required.

Type VI Flume: A type VI flume is a flume that uses the channel bed gradient to achieve supercritical flow conditions. There is no contraction in the flume width as occurs with the Parshall and cutthroat flumes. A slope of one degree is usually sufficient to produce critical depth in the vicinity of the upstream edge of the flume. However, a slope ranging from two to five percent is better because it prevents the creation of waves and disturbances that could hinder free flow downstream.

Depth Measuring Device: Flumes are equipped with standard USGS vertical staff gages. The staff gages will be used to measure gage height to the nearest 0.02 of a foot.

2.1.4 Maintenance and Calibration Procedures

All flumes will be inspected prior to measurement of discharge to determine that the flume is discharging freely. Any problems observed during the inspection will be noted and reported in the field book.

2.1.5 Field Procedures

If the site is equipped with a Parshall or cutthroat flume, then discharge will be measured according to the following procedures:

- Remove any material that may have accumulated in the flume
- Note any deterioration of the flume
- Measure and record the throat width to the nearest 0.01 of a meter
- Record the time and date of the site visit
- Use the staff gage to measure and record the gage height to the nearest 0.01 of a meter
- Calculate discharge from the stage/discharge table
- Record the calculated discharge

For the type VI flume, a stage/discharge curve must be developed. The following steps will be used to develop the curve.

- Remove any material that may have accumulated in the flume
- Record the staff gage height to the nearest 0.01 meter
- Determine the discharge through the flume using the velocity-area method (see following section)
- Plot the staff gage height against the measured discharge and fit the points with a regression line
- The stage/discharge curve will be most accurate if several points are plotted for low flow, moderate flow and peak flow conditions.

After the curve has been developed, future flow measurements are calculated by reading the staff gage height and using the stage/discharge curve to estimate the corresponding discharge. The curve should be verified periodically by using the velocity-area method to measure the discharge and checking it against the established curve.

2.2 VELOCITY-AREA METHOD

Surface flow in open conduits such as stream channels that are greater than 1-foot wide, or where flow exceeds 2.0 cfs, will be measured by using the velocity-area method.

Vertical Axis Current Meter

The vertical axis current meter is one type of meter that is commonly used. It is desirable for the following reasons:

- This meter operates in lower velocities than the horizontal-axis meter
- Bearings are well-protected from silty water
- Rotor can be repaired in the field without adversely affecting the measurement
- Single rotor serves for the entire range of velocities

A common type of vertical axis current meter is the Price current meter, Type AA. The standard Price meter has a rotor 5-inches in diameter and 2-inches high with six cone-shaped cups mounted on a stainless steel shaft. A pivot bearing supports the rotor shaft. The contact chamber houses both the upper pan of the shaft and a slender bronze wire ("cat's whisker") attached to a binding post. With each revolution, an eccentric contact on the shaft makes contact with a bead of solder at the end of the cat's whisker. A separate reduction gear (pentagear), wire, and binding post provide a contact each time the rotor makes five revolutions. A tailpiece keeps the meter pointing into the current.

In addition to the type AA meters, the USGS and others use a Price pygmy meter, a Swoffer meter, or similar device in shallow depths. The pygmy meter is scaled two-fifths as large as the standard meter and has neither a tailpiece nor a pentagear. The contact chamber is an integral part of the yoke of the meter. The pygmy meter makes one contact per revolution. The Swoffer is also a scaled meter, and also lacks a tailpiece or pentagear. The meter makes one contact per revolution, which is recorded on the digital display.

Marsh-McBirney Velocity Meter

Portable Marsh-McBirney flow meters are a type of current meter that may be used in the velocity area flow measurement. Either Model 201D or Model 2000 will be acceptable for the required gauging. The Marsh-McBirney meters measure flow velocity using the Faraday principle, which states that as a conductor moves through and cuts the lines of a magnetic flux, a voltage is produced. The magnitude of the generated voltage is directly proportional to the velocity at which the conductor moves through the magnetic field.

The Marsh-McBirney flow meter will be calibrated annually using a factory approved flow loop or tow tank. This procedure involves moving water past the meter at a known velocity or moving the meter at a known velocity through water. The velocity indicated by the meter is adjusted until the proper reading is obtained.

The sensor on the Marsh-McBirney meter can be connected to the universal sensor mount on the top-setting wading rod and used to determine flows using either the six-tenths depth method of the two-tenths and eight-tenths depths method. The minimum flow depth at which an average velocity can be measured with the Marsh-McBirney meter set at six-tenths of total depth is approximately 0.05 meters. Velocities can be estimated in flows as shallow as 0.03 meters. The meter is capable of measuring velocities ranging from 0.0 to 6 meters per second.

2.2.1 Theoretical Considerations

The volume rate of flow of water, which is commonly called discharge (Q), is the product of multiplying the average velocity (V) times the total cross-sectional area (A):

$$Q = VA$$

The current meter measures velocity at a point. The velocity-area method of making discharge measurements at a cross-section requires measurement of the mean velocity in multiple portions of the cross-section at each of the selected verticals. These are taken at subsections of the cross-section. A complete discussion of area-velocity methods is found in Rantz and others (1982).

By dividing the stream width into subsections, total discharge becomes the total of discharges measured in each subsection (see Figure 1). Individual point velocity (v) is measured at each subsection, and discharge becomes the sum of the products of each point velocity and cross-sectional area (a) of each subsection:

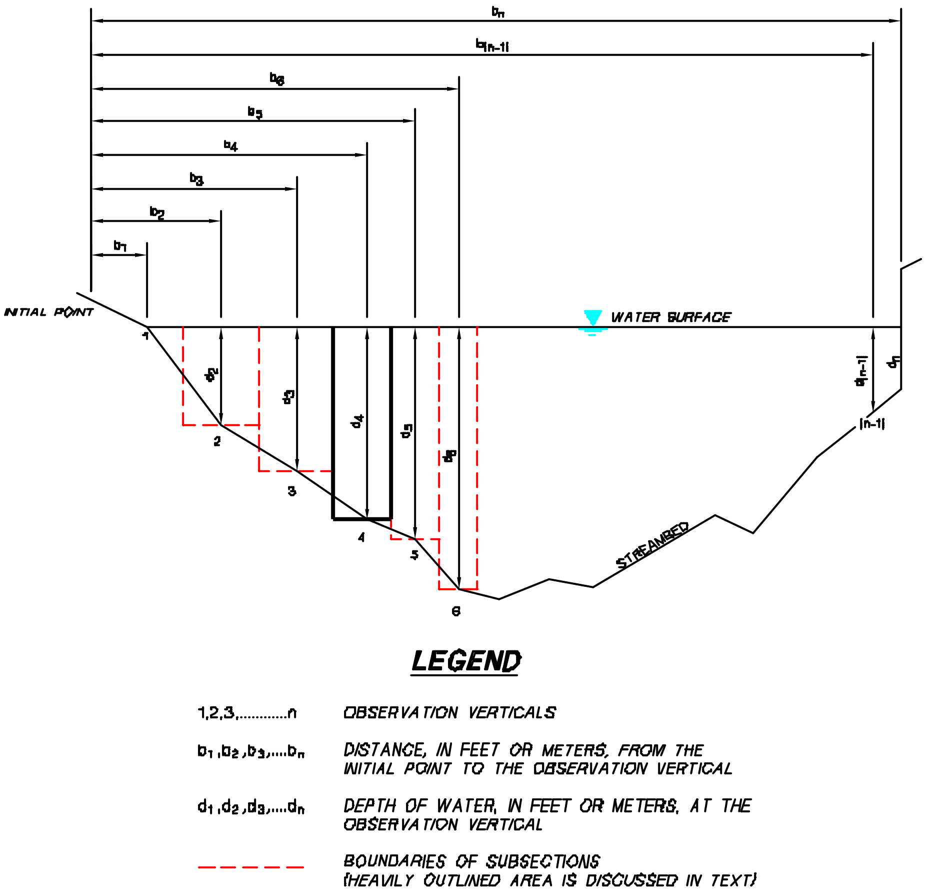
$$Q = Sva$$

where:
Q = total discharge,
v = point velocity, and,
a = area of the subsection.

Note that, in Figure 1, the cross-section is defined by depths at verticals 1, 2, 3, 4,... n. At each vertical, the average velocity is measured by a current meter.

The current-meter measurements performed in channelized streams will be based on selecting subsections to contain approximately 10 percent or slightly more of the total discharge. However, the stream should not be partitioned into sections that are significantly greater than 10 percent of the total stream flow because individual measurements that may be in error will then have a significant impact on the overall average velocity determination.

In general, depending on average depth and velocity distribution, a stream less than 2-feet wide will require no more than 8 to 10 subsections. A stream up to 4-feet wide will require about 10 to 12 subsections. Streams wider than 4-feet will require more subsections. Table 1 shows a breakdown of the number of recommended subsections. Further, subsections need not be of identical width. For example, because velocities near banks are generally lower than velocities near the center of streams, these subsections may be wider than subsections near the center. Subsections will also be more closely spaced if a stream has an unusually deep portion in the cross-section, or if velocities are higher than usual for the cross-section. Velocity will be observed at each point for a period that ranges from 40 to 70 seconds.



SOURCE: GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2175, 1982

SKETCH OF MID-SECTION METHOD OF COMPUTING CROSS-SECTION AREA FOR DISCHARGE MEASUREMENTS
FIGURE 1

TABLE 1 NUMBER OF SUBSECTIONS BASED ON STREAM WIDTH		
Approximate Width (feet)	**Approximate Number of Subsections**	**Approximate Distance between Subsections (feet)**
< 2	8 – 10	0.2 – 0.3
2 – 4	10 – 12	0.3 – 0.4
4 – 10	12 – 15	0.4 – 0.7
10 – 20	15 – 20	0.7 – 1.0
> 20	20 – 25	1.0 – 3.0

2.2.2 Required Measurement Conditions

In order to make a velocity-area discharge measurement, the following conditions are required:

- The stream must be channelized: that is, observable banks must channel the stream flow.
- Depth must be greater than 0.2-feet across most of the cross-section being measured.

- The stream must have measurable velocity of at least 0.2 feet per second (fps) in most of the cross-section, although the pygmy meter is capable of measuring velocity as low as 0.070 fps.

The first two conditions can often be met in streams of very low discharge by conservatively modifying the stream channel to produce a narrower and slightly deeper cross-section in order to meet measurement requirements. These modifications will include removal of aquatic growth or ice, moving large stones which impact velocity upstream or downstream of the cross-section, and narrowing or deepening of the cross-section. By rearranging small amounts of native rock or sand, the technician will produce a measurable cross-section. After thus clearing the cross-section, flow will be allowed to stabilize before the current-meter measurement of velocities begins.

Current meter measurements are best made by wading, if conditions permit. The Price AA, Pygmy, Swoffer, or Marsh-McBirney meters are used for wading measurements. Table 2, Current Meter and Velocity Method for Various Depths, lists the optimal type of meter and velocity method for wading measurements at various depths. A discussion of Table 2 follows the table.

TABLE 2
CURRENT METER AND VELOCITY METHOD FOR VARIOUS DEPTHS (ft)

Depth, in feet	Meter	Velocity Method (% of Depth)
1.5 – 2.5	Type AA or Swoffer	0.6
0.3 – 1.5	Pygmy or Swoffer	0.6
< 0.3	Pygmy or Swoffer	0.5

Some departure from Table 2 is permissible depending on the type of meter available. The type of meter used will be documented in the field logbook. In the 0.6-depth method, an observation of velocity made in the vertical at 0.6 of the depth below the surface is used as the mean velocity in the vertical. The 0.5-depth method will be used in very shallow stream conditions, with depths of less than 0.1 meters. This method requires that the meter be set at one-half the depth of water at the point, or at the lowest setting on the rod.

Vertical axis current meters do not register velocities accurately when placed close to a vertical wall. A Price meter held close to a right-bank vertical wall will under-register because the slower water velocity near the wall strikes the effective (concave) face of the cups. The converse is true at a left-bank vertical wall. (The terms "left bank" and "right bank" designate direction from the center of a stream for an observer facing downstream). The Price meter also under-registers when positioned close to the water surface or close to the streambed.

2.2.3 Equipment

Current meters, timers, depth and width measuring devices, and a means of counting meter revolutions are needed for measurement of discharge. The equipment includes:

- Depth-measuring device, the wading rod
- Current meter with digital read-out (or data logger)
- Width-measuring devices, either engineer's tape or tagline
- Stop watch

<u>Depth-Measuring Device.</u> The depth-measuring device that will be used is the topsetting wading rod. The current meter is attached to the wading rod. The top-setting wading rod consists of a main rod for measuring depth and a 3/8-inch diameter round rod for setting the position of the current meter.

<u>Current Meter.</u> A current meter is an instrument used to measure the velocity of flowing water. The principle of operation is based on the proportionality between the velocity of the water and the resulting angular velocity of the meter's rotor. By placing the current meter at a point in a stream and counting the number of revolutions of the rotor during a measured interval of time, the velocity of water at that point is determined.

The number of revolutions of the rotor is obtained by an electrical circuit through the contact chamber. Contact points in the chamber are designed to complete an electrical circuit at selected frequencies of revolution. The contact chambers have contact points that will complete the circuit once per revolution. The electrical impulse is then digitally recorded. The intervals during which meter revolutions are counted are timed with a stop watch.

Engineer's Tape or Tagline. Steel tapes, metallic tapes, or premarked taglines are used for width determinations during discharge measurements made by wading. Orientation normal to the flow pattern of the river and elimination of most of the sag, through support or tension, are recommended for improved accuracy.

Stop Watch. A stop watch is used to measure time during which velocity is measured at each point in the cross-section. Velocity at each point is measured for a period greater than or equal to 40 seconds and less than or equal to 70 seconds.

2.2.4 Maintenance and Calibration Procedures

Prior to use of the current meter, spin tests will be conducted to ensure that the unit performs acceptably. The spin test will be performed in an enclosed area, such as in the cab of a truck, to prevent wind interference. The test is to be performed prior to attaching the current meter to the wading rod. While holding the meter steady in an area sheltered from breezes, the technician will spin the rotor and then press the start button on the stop watch. The technician will observe the meter until the rotor ceases to spin.

The duration of the spin for the pygmy or Swoffer meter should be more than 40 seconds and for the Price AA meter should be more than 90 seconds. If the meter fails to meet the time-of-spin criteria, the meter will be cleaned and oiled before use. If the meter continues to spin well beyond these time limits, the record will indicate that the meter spun for 40+ seconds, in the case of the pygmy or Swoffer meter, or for 90+ seconds, in the case of the Price AA meter.

To assure reliable observations of velocity, it is necessary that the current meter be kept in good condition. Before and after each discharge measurement, the meter cups or vanes, pivot and bearing, and shaft should be examined for damage, wear, or faulty alignment. During measurements, the meter will be observed periodically when it is out of the water to be sure that the rotor spins freely.

Meters will be cleaned and oiled daily when in use. If measurements are made in sediment-laden water, the meter will be cleaned immediately after each measurement. After oiling, the rotor will be spun to make sure that it operates freely. If the rotor stops abruptly, the cause of the trouble will be sought and corrected before using the meter.

In addition to meter maintenance, the entire unit, consisting of current meter, wading rod and digital counter will be checked before departure to the field each day.

2.2.5 Field Procedures

Overview. A Price AA meter, Swoffer meter, or equivalent, will be selected to perform a velocity-area measurement. Neither the type AA meter nor the Swoffer meter should be used for measuring velocities slower than 0.1 fps unless absolutely necessary. If depths or velocities under natural conditions are *too* low for a dependable current meter measurement, the cross-section will be modified, if practical, to provide acceptable conditions. A shovel will be used to remove aquatic vegetation, ice, or rocks, which may interfere with meter operation or discharge measurement.

At each measurement point (or station) across the stream cross-section, depth is measured prior to measurement of velocity. Therefore, it is recommended that the wading rod be set with the current meter suspended out of the water and above the tagline, which is used to measure width and to identify stations across the cross-section. Placement of the rod about 0.5-feet downstream from the tagline prevents contact between the tagline and the current meter when the meter is lowered into measuring position.

The wading rod will be placed in the stream so the base plate rests on the streambed, and the depth of water will then be read from the graduated main rod. The main rod is graduated into 0.1-foot increments: these increments are indicated by a single score in the metal. Increments of 0.5-foot are marked by two scores in the metal, and one-foot increments are marked by three scores in the metal. A vernier scale on the upper handle of the rod corresponds to 0.1-foot increments, and has 1 through 9 in raised numbers next to raised marks. A sliding, adjustable rod, known as the setting rod, to which the meter is attached, has single scored marks which are aligned with values on the vernier scale.

The hydrographer reads water depth directly from the main rod. In high velocity areas, it is recommended that depth be read as the value between the depth on the upstream side of the rod and the depth on the downstream side of the rod. Depth is measured to the nearest 0.1-foot. This depth is used to set the vertical location on the current meter.

The setting rod is next adjusted downward so that the scored mark of the setting rod which corresponds to the range of depth in 0.1 meters (e.g., if depth = 0.46, range in feet = 0; or if depth = 1.23, range in feet = 1) is aligned with the stream depth value transposed to the vernier scale. This automatically positions the meter for use in the 0.6 method as the meter is then six-tenths of the total depth from the surface of the water. If depths are less than 0.3-feet, the 0.5 method may be used. The observation depth recorded will then be 0.5 of the total depth.

The hydrographer will stand in a position that least affects the velocity of the water passing the current meter. That position is obtained by facing upstream while holding the wading rod vertically and close to the tagline or measuring tape. The hydrographer stands at about a 45-degree angle downstream from the wading rod and at least 1.5-feet meters from the wading rod. This angle is an imaginary angle between the extended arm holding the wading rod and the tagline or measuring tape. The hydrographer should avoid standing in the water if his or her feet and legs occupy a significantly large percentage of a narrow cross-section. For narrow streams, it is often possible to stand astride the stream.

The wading rod should be held in a vertical position with the meter parallel to the direction of flow while the velocity is being observed. When measuring streams that have shifting beds, the soundings or velocities can be affected by the scoured depressions left by the hydrographer's feet. For such streams, the meter should be placed ahead of and upstream from the hydrographer's feet.

Once the velocity-area measurements have all been taken, measure and record the gage height from the staff gage to the nearest 0.02-foot again.

<u>Steps to be Followed in Measuring Discharge.</u> Water quality and bed material samples will be collected prior to making discharge measurements. The following steps are to be followed in discharge measurement:

- Use the staff gage to measure and record the gage height to the nearest 0.02 of a foot.

- Measurement notes are recorded on the Surface Water Data Collection Form at each subsection of the cross-section as the measurement is performed.

- If two people are performing the measurement, the hydrographer may state the stations, depths, counts, and number of seconds to a note keeper. The note keeper would then repeat each value stated by the hydrographer to assure agreement between the value stated by the hydrographer and the value heard by the note keeper.

- Record on the field data collection form the following: distance from initial point, width, depth, observation depth, revolutions, time in seconds, velocity, area, discharge.

- Note the distance in meters in terms of stream direction that this cross-section lies from the prescribed location. For example, the note may read "25 feet downstream" or "15 feet upstream." This is recorded in a manner similar to that on the front of the discharge measurement note.

- If the selected cross-section contains aquatic growth, ice, boulders, or slack-water areas that can either interfere with operation of the current meter or otherwise impede accurate measurement, use a shovel to remove minor flow impediments.

- Position a tape (for small streams) or the tagline (for large streams) about one-foot above the surface of the water. Secure the tape so that it remains taut and perpendicular to the channel.

- Select a starting point at either the left bank (left edge of water, LEW) or the right bank (right edge of water, REW), which is determined by facing downstream.

- Measure the width of the stream in meters. Select the number of subsections in which to measure velocity. The goal in selection of measurement stations is to measure no more than ten percent of the total discharge in any given subsection. Subsections need not be identical in width. Use more observation points in deep areas or portions of the channel having higher velocities. Frequently, fewer observation points are needed near the shore than near the center of the stream. Obvious breaks in streambed configuration are also proper locations at which to measure velocities.

- After determining the distance desired between stations, measurement can begin. Record the time and bank at which measurement starts on the discharge measurement note as "REW Start 0000", using REW or LEW, depending upon whether starting at the right or the left edge of the water. 24-hour clock time is used, and is recorded to the nearest five minutes.

- Note the distance to the beginning edge of water from the initial point. The initial point is an arbitrary point on the tape, preferably a whole number, which lies on the shoreside of the stream. All subsequent station locations are recorded as distances from the initial point.

- Proceed to the first station. Record the distance from the initial point on the discharge note.

- Stand downstream of the tagline or tape and face upstream. Begin with the current meter on the wading rod well above the surface of the water.

- Measure stream depth at the measurement point on the wading rod. Individual lines on the wading rod indicate 0.1-foot increments; double lines indicate 0.5-foot increments, and triple lines indicate one-foot increments. Record the stream depth to the nearest 0.02-foot: for example 0.31 feet or 1.54 feet.

- Lower the meter to the required depth and record the observation depth in the logbook. The observation depth as a fraction of total depth is usually 0.6, or 0.5 for subsections having depth of less than 0.3 feet.

- Stand downstream of the meter with the arm fully extended as you hold the wading rod. Position yourself so that the angle measured between the arm and the tagline is about 45 degrees. Stand as far away from the vertically held wading rod as possible.

- Start the stopwatch.

- After at least 40, but as much as 70 seconds have passed, stop the stopwatch.

- Record velocity displayed on digital read-out on same line of the note as the depth.

- Proceed to the next station. Record the distance from the initial point to the station. Repeat measurements of depth and velocity. Continue in this manner across the stream.

- After recording the distance measurement at the last station, record the time at which the ending edge of water is reached as "LEW (or REW) FINISH 1330."

- Note velocity and depth at the edge of water as zero.

- Following velocity-depth measurements, use the staff gage again to measure and record the gage height to the nearest 0.02 of a foot.

- Evaluate and record on the data collection note the following: flow characteristics, weather, air temperature, water temperature, observer(s), type of meter, and remarks.

2.2.6 Discharge Calculations

A stream discharge is the summation of the products of the subsection areas of the stream cross-section and their respective average velocities. The formula Q = S(av) represents the computation, where Q is the total discharge, a is an individual subsection's area, and v is the corresponding mean velocity of flow normal to the subsection. The summation of the discharges for all the subsections is the total discharge of the stream. The order for calculating discharge is:

- Use the distances from initial point to compute width for each section. The first width is computed by subtracting the first distance from the second distance, and dividing this quantity by two. The second width will be the quantity of difference between the third distance and the first distance, divided by two. For each subsequent width, subtract the distance on the line above the line you are calculating from the distance on the line below the line you are calculating, and divide this quantity by two. This procedure is carried out for each line until you reach the final width calculation. This is calculated as the quantity of the difference between the final distance and the second-to-the-last distance, divided by two.

- Subsequent calculations will be performed as follows:

    < Calculate each discharge for each subsection by multiplying the width of the subsection times the depth times the velocity.
    < Sum the discharges for each subsection to arrive at total discharge for the entire cross-section.

- Check your math by summing the subsection widths. Their total should equal the value obtained by taking the difference between the LEW and the REW station distances from initial point.

- Initial at the line "Comp. by" to identify yourself as the person responsible for performing the discharge calculation.

2.3 VOLUMETRIC METHODS

The volumetric method is a simple and accurate method for measuring flow from small discharges such as gravity flow discharges from pipe outlets.

2.3.1 Theoretical Considerations

This method involves measuring the time required to fill a container of known capacity, or the time required to partly fill a calibrated container to a known volume. Alternatively, in the case of measuring discharge remotely in a sump or standpipe setting, the volumetric method may be performed by capturing flow in a container for a set period of time.

2.3.2 Required Measurement Conditions

Conditions must be such that all discharge from an outlet can be captured in the volumetric container during the period of measurement.

2.3.3 Equipment

The bucket and stop watch technique is particularly useful for the measurement of small flows. Equipment required to make this measurement is a calibrated container and a stopwatch. Calibrated containers of varying sizes will include:

- 5-gallon bucket
- 2-liter graduated cylinder
- 1-liter graduated cylinder
- 1-liter bucket
- 500-milliliter beaker
- 250-milliliter beaker

2.3.4 Maintenance and Calibration Procedures

Graduated cylinders are incremented in terms of milliliters and can be easily converted to gallons. The incremental volume of a 5-gallon bucket can be determined by adding known volumes of water and recording the depth after each addition.

2.3.5 Field Procedures

Upon arrival at the site, the sampling personnel will evaluate the flow conditions to select the appropriate method for flow measurement. If flow conditions are appropriate for volumetric measurement, the sampling personnel will observe and use judgement in approximating the flow volume and will select an appropriately sized volumetric container.

Sampling personnel will use a stopwatch to measure the time required to fill a volumetric container. Three consecutive measurements will be made and noted, and the results will be averaged to determine the discharge.

2.3.6 Discharge Calculations

Discharge will be determined initially in gallons per second (gal/s) or in milliliters per second (ml/s). These values will be noted, but the average value will be reported in cubic meters per second. Calculations will be performed as follows:

- Record each of the three measurements in terms of gallons per second or milliliters per second, depending on the volumetric container.

- If one of the three measurements is 50 percent or more different from the other two measurements, then this value will not be used. Instead, three additional measurements will be taken and, provided that none of these three measurements differs by greater than 50 percent from the other two measurements, these values will be used.

- Average the three values.

- Convert the averaged value to cfs as follows:

    < To convert ml/s to cfs, multiply by 3.5×10^{-5}
    < To convert gal/s to cfs, multiply by 0.134

- Record discharge in cfs (gpm for seeps, springs and low-flow pipes).

3.0 REFERENCES

Rantz, S.E., et al. Measurement and Computation of Streamflow: Volume I and II; Measurement of Stage and Discharge; Computation of Discharge. Geological Survey Water-Supply Paper 2175. U.S. Government Printing Office. Washington, D.C. 1982.

U.S. Department of the Interior. National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, Geological Survey. Reston, VA, 1977.

U.S. Department of the Interior. Hydraulic Measurement and Computation: "Discharge Measurements at Gaging Stations." Book 1, Chapter 11, Geological Survey. Reston, VA. 1965.

ATTACHMENT A

FIELD DATA SHEETS

SURFACE WATER DISCHARGE FORM

DIST FROM INITIAL POINT	WIDTH (ft)	DEPTH (ft)	OBSER DEPTH	REVS	VELOCITY (M/S)		AREA (ft^2)	DISCHARGE (cfs)
					TIME (SEC)	AT POINT		
	REW or LEW (circle one) at time =							
	REW or LEW (circle one) at time =							

REW = Right Edge of Water (viewed downstream)
LEW = Left Edge of Water (viewed downstream)

STANDARD OPERATING PROCEDURE

SOP-4

GROUNDWATER LEVEL MEASUREMENT

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1.0 PURPOSE

The purpose of this technical procedure is to establish a uniform and consistent procedure for measuring water levels in wells, piezometers and boreholes.

The groundwater level measurement procedures presented in the following sections were developed using standard industry-accepted practices, as well as international organization and agency guidelines and standard practices. The same care must be exercised in implementing field investigations and sampling events that are exercised in planning the program design and analyzing samples in the laboratory. No analytical result is better than the sample from which it was obtained.

Specific organizations and agencies with guidelines and standard procedures that were used include:

- U.S. Environmental Protection Agency (EPA)
- State of Nevada (U.S.) Division of Environmental Protection (NDEP)
- American Society of Testing and Materials (ASTM)

2.0 DEFINITIONS

2.1 ELECTRIC WATER LEVEL SOUNDER (EWS)

An electronic water-level sounder (EWS) is an instrument for measuring water levels in wells, piezometers and boreholes. An EWS is essentially an open circuit involving an ammeter and battery mounted on a reel to which an insulated two-wire electric cord (calibrated by length) is wound. The circuit is closed, and a buzzer sounds when the electrodes on the probe are immersed in water. Depth to water is recorded at the depth where the buzzer sounds.

3.0 DISCUSSION

Measurement of static water levels may constitute a separate task or be performed in conjunction with groundwater sampling. Prior to any purge sampling activity at each monitor well, a water level measurement is required to be taken. Measurement of the static water level is important in determining the hydrogeologic characteristics of the groundwater system.

Prior to taking the EWS to the field, check that the EWS is functioning properly and that the batteries are in working order by turning instrument on and pushing the test button located on the side of the instrument. Also verify that the probe is functioning properly by submerging it in tap water. Both the audio and visual signals should function.

Decontaminate the probe and cord of the EWS using Alconox or equivalent non-phosphate detergent and distilled water. Rinse a minimum of three (3) times with distilled water. At a minimum decontaminate the probe and the length of reel you believe will be in the well plus an additional 3 meters.

The measurement will be referenced from the reference point marked on the top of the well casing; this is typically located on the north side of the casing. The measurement to the static water level in the well will be to the nearest 0.01-foot interval. The measurement will be immediately repeated to verify the accuracy of the initial reading. The depth to water measurement will be compared in the field to previous measurements to verify that the measurement is reasonable. Record the depth to water level on the field logbook and Record of Water Level Readings form (see Exhibit A). Other items to record include well identification number, casing diameter, vertical height of measuring point above ground surface, and time and date of measurement.

If depth to water is measured in an open borehole, note that the reference level is ground surface. Also note, especially if the ground is uneven, from which side of the borehole (i.e. north, etc.) the measurement was referenced.

In addition, it is good practice to periodically measure total well depth, since silt can build up and decrease the total depth of the well. Measure the total depth of the well following determination of static water level. If using the EWS to determine the depth of the well, make sure that the additional cable that will be submerged has been decontaminated and that the probe tip length is added to the total depth measured. Total well depth measurement also ensures that the well is in good condition to total depth.

4.0 EQUIPMENT AND MATERIAL

The following is a list of equipment that should be available in the field to perform water level measurements.

- Electric Water-level Sounder or Measuring Tape with a Wetable Surface
- Folding Rule
- Field logbook or field data sheet (see Record of Water Level Readings form, found in Exhibit A)
- Data on Well Identification Number and Locations
- Spare Battery for Electric Water-level Meter
- Permanent, waterproof pens

5.0 PROCEDURES

- Record well identification number and measuring device type and serial number.
- Each water level sounder or measuring tape used for recording water levels should have the depth graduations checked with an independent folding rule or measuring tape for calibration prior to field use.
- Clean all downhole instruments and equipment before and after measurements between wells. Cleaning should be with a non-phosphate detergent rinse followed by a rinse with approved tap water, then rinse with organic free distilled or deionized water.
- Measure and record distance from ground level to top of casing or standpipe. Measure the vertical distance from the top of casing or standpipe to the point of the elevation survey mark (if different from top of casing or standpipe).
- If an EWS is used, turn on the EWS, check the battery, lower the wire into the borehole or standpipe and stop at the depth where the EWS meter indicates a repeatable, completed circuit. Record the length of the wire below the casing collar or top of the standpipe to the nearest 0.01-foot.
- If a measuring tape is used, lower the tape (with a weight attached) into the borehole. The tape must be lowered a sufficient depth into the well to ensure the wetable surface section of the tape is partially submerged. The total length of the tape within the well (from the top of casing or standpipe) and the length of the wetted surface to the submerged end of the tape will be recorded.
- Record date, time, well designation, measuring device and all measurements on a Record of Water Level Readings form (Exhibit A), and bound logbook. The personnel making the measurement will initial or sign each measurement recorded. All water level measurement records will be maintained in the project records files.

6.0 REFERENCES

American Society of Testing and Materials (ASTM). 1994. *Standards on Ground Water and Vadose Zone Investigations.* Second Edition. ASTM Committee D-18 on Soil and Rock. Philadelphia, Pa.

American Society of Testing and Materials (ASTM), 1995. *ASTM Standards on Environmental Sampling*. PCN-03-418095-38, Philadelphia, Pa.

U.S. Environmental Protection Agency (EPA), 1994. *Standard Operating Procedures for Field Sampling Activities, Version 2.* EPA Region VIII, Denver, Colorado.

U.S. Environmental Protection Agency (EPA), 1995. *Standard Operating Procedures for Water Level and Non-Aqueous Phase Liquid (NAPL) Measurements in Boreholes and Monitoring Wells, Version 1.* EPA Region VIII, Denver, Colorado.

EXHIBIT A

RECORD OF WATER LEVEL READINGS

RECORD OF WATER LEVEL READINGS

Job No. ____________________ **Project No.** _________________________ **Location** ___________________

Borehole No.	Date	Time	Measuring Device	Reading	Corrections Or Conversions	Water Level	Surf. Elev.	Water Level Elev.	By	Comments

STANDARD OPERATING PROCEDURE

SOP-5
COLLECTION OF NEAR-SURFACE SOIL SAMPLES

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1.0 INTRODUCTION

This standard operating procedure (SOP) describes methods and equipment commonly used for collecting environmental samples of near-surface soil and mine waste material media for either on-site examination and chemical testing or for laboratory analysis. It also describes procedures for sample handling, labeling and documentation.

The information presented in this SOP is generally applicable to all environmental sampling of near-surface soil and mine waste material except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions, and equipment different from those described herein.

Specific sampling problems may require the adaptation of existing equipment or design of new equipment. Every field investigation must be conducted in accordance with an approved quality assurance project plan (QAPP). The QAPP identifies the minimum procedures required to assure that goals for precision, accuracy, completeness, representativeness, and comparability of data generated are satisfied. In addition to the QAPP, every field program must have a site-specific field sampling plan (FSP) that defines the proper procedures to be followed in the collection, preservation, identification and documentation of environmental samples and field data.

The same care must be exercised in implementing field investigations and sampling programs that are exercised in planning the program design and analyzing samples in the laboratory. No analytical result is better than the sample from which it was obtained.

Specific organizations and agencies with guidelines and standard procedures that were used include:

- U.S. Environmental Protection Agency (EPA)
- State of Nevada (U.S.) Division of Environmental Protection (NDEP)
- American Society of Testing and Materials (ASTM)
- U.S. Department of the Interior, Geological Survey (USGS)

2.0 DEFINITIONS

Surface soil: The soil that exists down from the surface approximately one foot (12-inches). Depending on application, the soil interval to be sampled will vary.

Grab Sample: A discrete portion or aliquot taken from a specific location at a specific point in time.

Composite: Two or more subsamples taken from a specific media and site a specific point in time. The subsamples are collected and mixed, then a single average sample is taken from the mixture.

Spoon/Scoop: A small stainless steel or Teflon utensil approximately 6- to 8-inches in length with a stem-like handle.

Trowel: A small stainless steel or Teflon shovel approximately 6- to 8-inches in length with a slight curve across the blade. The trowel has a stem-like handle. Samples are collected with a spooning action.

3.0 SAMPLING PROCEDURES

3.1 BACKGROUND

Near-surface soil and mine waste material samples are collected to determine the type(s) and level(s) of contamination. These samples may be collected as part of an investigation plan, site-specific sampling plan, and, or as a screen for "hot spots", which may require more extensive sampling. Sediment(s) and sludge(s) that have been exposed by evaporation, stream rerouting, or any other means are collected by the same methods as those for surface soil(s). Typically, the top one-inch of material, including vegetation, are carefully removed before collection of the sample.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important element not only for assessment and quantification of environmental impact to, or posed by, the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a representative sample has been taken. To collect representative samples, sampling bias related to site selection; sampling frequency; sample collection; sampling devices; and sample handling, preservation, and identification must be minimized.

3.2 DEFINING THE SAMPLING PROGRAM

Factors that shall be considered in developing a sampling program for near-surface soil include study objectives; accessibility; site topography; physical characteristics of the medium; point and diffuse sources of contamination; and personnel and equipment available to conduct the investigation(s).

3.3 SAMPLE COLLECTION

The following steps must be followed when preparing for sample collection:

- The collection points shall be stated, located on a map, and referenced in the field logbook.
- Processes for verifying depth of sampling must be specified in the site-specific field sampling plan.
- Place clean plastic sheeting on a flat, level surface near the sampling area, if possible, and place decontaminated equipment to be used on the plastic. Cover all equipment and supplies with clean plastic sheeting when not in use.
- A clean, decontaminated trowel, scoop, or spoon will be used for each sample collection.

The selection of sampling equipment depends on the site conditions and sample type required. The most frequently used samplers are:

- Hand auger
- Trowel
- Scoop or spoon
- Back-hoes
- Drill rigs

A trowel, scoop/spoon or hand auger are used most often.

The criteria for selecting a sampler include:

- Ease of disposal and, or decontamination.
- Relative expense (if the item is to be disposed of).
- Ease of operation, particularly if personnel protection required is above Level D.
- Reactivity/contaminating potential - Stainless steel, Teflon, or polyethylene sampler are preferred (in that order). Back-hoes may be used to collect samples from shallow trench walls; the bucket must be free of rust, grease and point. Only soil which has not been in contact with the bucket may be sampled.

3.3.1 Saturated Soil Paste

Saturated soil pastes are used in to field characterize soil medium Paste pH indicates the degree of acidity or alkalinity in soil materials. Paste conductivity indicates the total concentration of ionized constituents of soil extract solutions. These measurements will be useful in determining the solubility of soil minerals, the mobility of ions in the soil, potential soil toxicity and assessing the viability of the soil-plant environment.

The following procedures will be used to prepare and measure saturated soil pastes in the field environment.

- Identify a minimum of three sub-samples of the soil material of interest.
- Collect approximately two (2) pounds of soil material (0 to 12-inch depth) at each sub-sample location and composite into a large, decontaminated stainless steel mixing bowl or high-density polyethylene (HDPE) bucket.
- Prepare a composite sample by thoroughly mixing the sub-sample material.
- Fill a 250 millimeter (ml) beaker with 100 ml of the sample.
- Add distilled water to the sample (approximately ¼ to ½ the volume of the soil sample) while stirring the mixture with a decontaminated stainless steel spatula (or equivalent).
- At saturation the soil paste glistens as it reflects light, flows slightly when the container is tipped, and the paste flows freely and cleanly of the stirring apparatus. If excess water has been added to the sample, add small amounts of additional soil with mixing to absorb the excess water.
- After mixing, the sample should be allowed to stand for a minimum of one (1) hour.
- The pH of the paste is measured directly by slowing inserting the pH probe into the paste and waiting for the reading to stabilize.
- To determine the conductivity of the paste:
    - set up a vacuum filter apparatus (e.g., peristaltic pump) with a 0.45 micron disposable filter;

- use the vacuum device to separate the liquid filtrate from the paste, collecting the filtrate in a collection beaker;
- collect approximately 25 ml of filtrate;
- measure the conductivity of the filtrate by placing the conductivity probe directly into the filtrate and waiting for the reading to stabilize.

- Record the values in the field notebook.

3.3.2 Direct Collection

The following procedure will be used to collect near-surface soil and mine waste material samples.

- Identify a minimum of three sub-samples of the soil material of interest.
- Collect approximately two (2) pounds of soil material (0 to 12-inch depth) at each sub-sample location and composite into a large, decontaminated stainless steel mixing bowl or high-density polyethylene (HDPE) bucket.
- Prepare a composite sample by thoroughly mixing the sub-sample material.
- Fill the pre-labeled sample container the composited material.
- Upon completion of the sampling, the excess material removed from the hole and not used as sample will be used to backfill the hole.
- After each composite sample is obtained, all equipment used in the sampling process, including shovels, trowels, spoons, and bowls will be decontaminated prior to reuse.

3.3.3 Decontamination of Field Equipment

The sample collection equipment will be decontaminated at each monitoring location. The following guidelines will be used to decontaminate sampling equipment:

- Gross contamination on equipment will be scraped off at the sampling site.
- Equipment that will not be damaged by water will be washed with the Alconox (or a comparable non-phosphate), biodegradable detergent. Equipment will be triple rinsed with potable water followed by a triple distilled or de-ionized water rinse.
- Equipment that may be damaged by water will be carefully wiped clean using a sponge and detergent water, and rinsed with distilled or de-ionized water. Care will be taken to prevent any equipment damage.
- All non-dedicated equipment will be decontaminated between each sample location. When purging groundwater monitoring wells, meter probes will be rinsed with distilled or de-ionized water between each casing volume measurement. After collecting the sample follow the full decontamination procedures.
- Rinse and detergent waters will be replaced with new solutions between sampling events.

Following decontamination, equipment will be placed in a clean area or in clean plastic bags to prevent contact with soils/sediments and airborne material that could contaminate a future sample.

4.0 SAMPLE HANDLING AND FIELD DOCUMENTATION

The purpose of this section is to define the standard protocols for sample handling, documentation and chain-of-custody. The use of proper documentation and chain-of-custody procedures will assure that the adequacy of the sample collection methods and handling can be evaluated.

4.1 SAMPLE HANDLING

4.1.1 Sample Containers

Proper sample preparation practices will be observed to minimize sample contamination and potential repeat analyses due to anomalous analytical results. Prior to sampling, sample bottles will be obtained directly from the analytical laboratory, or laboratory supply-house. The bottles will be labeled (see following section) to indicate the type of sample and sample matrix to be collected. Sample bottles can be either pre-preserved from the laboratory or preservatives can be added in the field during sample collection. In general, 0.5-liter or 1-liter polyethylene or glass bottles will be used for the sample bottles that will be submitted for analysis of general chemical constituents, major inorganic constituents and metals.

Laboratory sample containers will be filled one by one at the monitoring location, secured with the container lid, and any excess soil wiped off the exterior. Immediately after collection, the containers will be placed in field coolers with ice. Glass containers will be wrapped with bubble wrap or other appropriate shipping material to prevent breakage.

4.1.2 Sample Preservation

Samples are preserved in order to prevent or minimize chemical changes that could occur during transit and storage. Sample preservation should be performed immediately upon sample collection to assure that laboratory results are not compromised by improper coordination of preservation requirements and holding times. Samples will be preserved immediately and stored on ice in coolers prior to shipping. Sample preservation requirements are based on the most current publication of 40 CFR, Part 136.3 (U.S. Federal Register).

For all samples, preservation by cooling to 4°C is required immediately after collection while the samples are held for shipment and during shipment to the laboratory.

4.1.3 Sample Holding Times

Sample holding times are established to minimize chemical changes in a sample prior to analysis and, or extraction. A holding time is defined as the maximum allowable time between sample collection and analysis and, or extraction, based on the nature of the analyte of interest and chemical stability factors.

In general, soil or solid matrices do not have holding times. However, most samples will be shipped to the analytical laboratory in iced coolers within 48 hours of collection, if conditions permit**.**

4.1.4 Sample Preparation and Shipping

After collection, samples will be labeled and prepared as described above, and placed on ice in an insulated cooler. The sample containers should be placed in re-sealable plastic storage bags. Samples should be stored in an upright position. Coolers sent to the analytical laboratories should be chilled with ice. The coolers will be taped shut and chain-of-custody seals will be attached to the outside of the cooler to assure that the cooler cannot be opened without breaking the seal.

4.2 FIELD DOCUMENTATION

Documentation establishes procedures, identifies written records, enhances and facilitates sample tracking, standardizes data entries, and identifies and establishes authenticity of the sample data collected. Proper documentation also:

- Assures that all essential and required information is consistently acquired and preserved;
- Documents timely, correct, and complete analysis;
- Satisfies quality assurance requirements;
- Establishes chain-of-custody;
- Provides evidence for court proceedings; and,
- Provides a basis for further sampling.

4.2.1 Sample Labels

Samples collected will be identified by a sample tag attached to the sample bottle. A sample tag or label will be completed and attached to each laboratory sample container just before it is filled. The labels will be filled out with a permanent marker and will include the following information:

- Sample identification
- Sample date
- Sample time
- Sample preservative (if any)
- Sample type (including if raw or field filtered)

Because a variety of preservatives and analytical methods will be employed, care must be taken to avoid mislabeling the containers. If possible, labels should be covered with plastic tape to minimize smudging and ink runs.

4.2.2 Sample Identification

Each sample will be given a unique identification number. This number will identify the date of sampling, sample matrix, the location identification number, and, if appropriate, a quality control suffix. To avoid confusion between primary samples and quality control samples, duplicate samples will be designated with a "D", triplicate samples will be designated with a "T", field blank samples will be designated with a "B", and equipment blanks will be designated with a "E" suffix in the station identification name. For example:

station identification number-quality control suffix

SW-2-D

The above sample identification represents a soil <u>duplicate</u> sample collected at SW-2.

4.2.3 Field Documentation

Appropriate field records will be completed in a bound field logbook and, or field data sheets at each site at the time of sample collection. All aspects of sample collection and handling as well as visual observations will be documented in the field logbooks. In general, field logbooks as well as field data records should:

- Record, identify and describe all pertinent sampling and monitoring activities.
- Record quantitative and qualitative information for each sample collected.
- Record and describe all field team activities, including observations and events.

At a minimum, the following information will be recorded in the field at each monitoring station:

- Site location
- Sampler name(s)
- Date and time of sample collection
- Sample identification number(s)
- Type of sample (soil, mine waste material, sediment)
- Field measurements, if applicable (paste pH and conductivity)
- Sample handling
- How sample collected (e.g. grab, composite)
- Number and type of any QA/QC samples collected
- Sample depth
- Weather conditions, including recent precipitation and approximate air temperature
- Field observations, including any unusual conditions or activities in the area

Changes or deletions in the field logbook should be lined out with a single strike mark and remain legible. Sufficient information should be recorded to allow the sampling event to be reconstructed without relying on the collector's memory. All field notebooks and data forms will be signed at the end of each day.

4.2.4 Chain-of-Custody

A chain-of-custody (COC) record is used to record the custody and transfer of all samples. The field sampler will be responsible for the care and custody of the water quality samples until they are transferred to a licensed courier. The sampler's responsibility will include:

- Labeling and sealing all sample containers (including custody seals, when appropriate);
- Properly packing the samples with ice for shipment to the laboratory;
- Notifying the courier about a sample pick-up and preparing any airbills for shipping samples to the laboratory;
- Initiating chain of custody forms; and,
- Notifying the laboratory of all sample shipments.

A chain-of-custody form will accompany each sample cooler and include the following information.

- Project name or number
- Sampler's name and signature
- Sample identification number(s)
- Date and time of sample collection
- Sample matrix
- Number of sample containers
- Analyses requested
- Method of shipment (with airbill number if applicable)
- Any additional instructions for the laboratory

Upon receipt, laboratory personnel will inspect the samples and record their condition and temperature on the chain-of-custody form. The laboratory will immediately report the presence of broken custody seals to MWH's project laboratory liaison. The laboratory liaison, after consulting with the Project Manager and the laboratory's project manager, will decide whether or not to analyze the samples. Decision criteria that will be used to help in determining if the samples should be analyzed include:

- If the cooler custody seal is broken is there any sort of documentation that may indicate who broke the seal, e.g., a customs declaration, or a notation from the shipping company;

  ➢ The samples can be analyzed

- If the cooler appears intact, and the samples inside are ok, e.g., the individual bottle custody seals are intact;

  ➢ The samples can be analyzed

- If the cooler custody seal, and the individual bottle seal(s) have been compromised;

  ➢ Then the samples <u>should not</u> be analyzed

The COC forms will be completed by the laboratory and forwarded with the final laboratory results.

4.3 SAMPLING CONTACT

Field sampling activities will be preformed under contract to MWH. MWH will work under the direction of Mr. Gary Aho of Cleveland-Cliffs, the RTWG Project Manager. Mr. Aho's address and phone number are provided below:

Mr. Gary Aho
Cleveland-Cliffs Iron Company
P.O. Box 1211
818 Taughenbaugh Boulevard
Rifle, Colorado 81650
(970) 625-2445

5.0 REFERENCES

American Society for Testing Materials (ASTM), 1995. *ASTM Standards on Environmental Sampling*. Philadelphia, PA.

U.S. Environmental Protection Agency (EPA), 1994a. *U.S. EPA Region VIII Standard Operating Procedures of Field Sampling Activities, Version 2*. June. Denver, CO.

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